THE ILLUMINATING ENGINEER

LIGHT
LAMPS
FITTINGS
AND
ILLUMINATION

THE JOURNAL OF
GOOD LIGHTING

Official Organ of the Illuminating Engineering Society
FOUNDED IN LONDON 1908

Edited by
J. STEWART DOW

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Special Features:

The Development of Illuminating Engineering in Europe—The Report of H.M. Chief Inspector of Factories—Lighting Institutes in Belgium and the United States—Glare and Visibility in Street Lighting—Modern Tendencies in Domestic Lighting—News from Abroad, etc.

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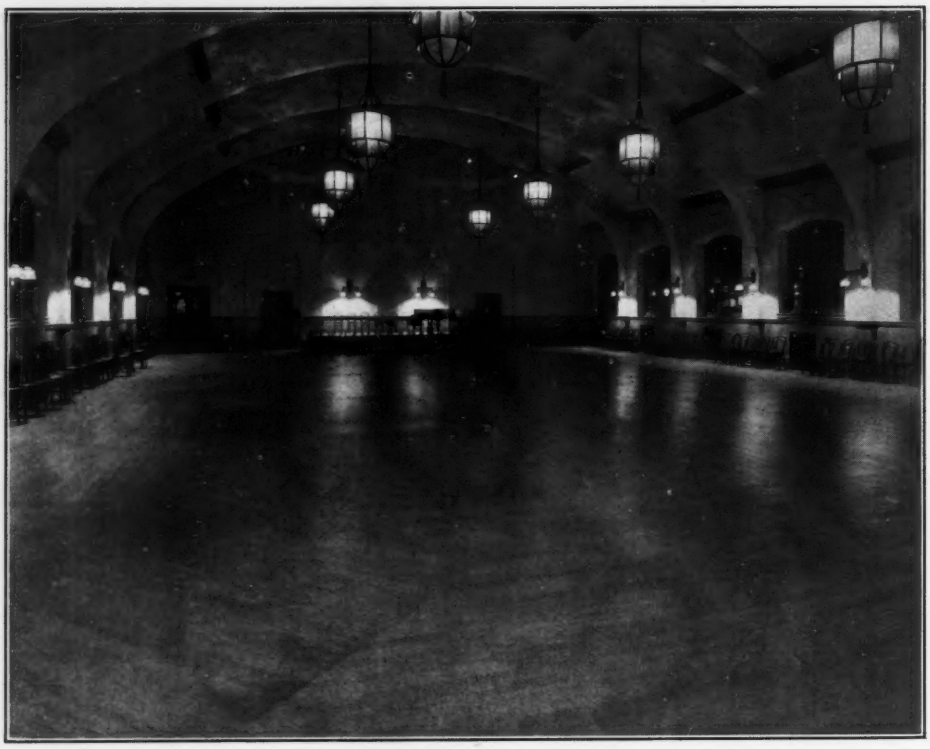

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Developments in Illuminating Engineering in Europe

AN instructive survey of the development of illuminating engineering in Europe is given in the three papers read by Mr. C. A. Atherton, Mr. W. E. Bush and Dr. E. Bausenwein, at the Annual Convention of the American Illuminating Engineering Society.* This subject is likewise dealt with in an address recently given before the Western Society of Engineers† by Mr. S. E. Doane, who was one of the first of engineers prominent in the lighting field in the United States to attempt a systematic survey of European conditions.

Interest in good lighting is being fostered by three main types of bodies—Government institutions, scientific and technical societies and trade organizations. It is gratifying to find that, although the methods adopted in the various European countries differ, these types of organizations have been generally most successful in working in harmony and dividing the educational work between themselves. The Illumination Research Committee, working under the Department of Industrial Research, seems to be almost unique; there seems to be nothing quite like it in other countries. One might perhaps say the same of the Lichttechnisches Institut in Karlsruhe, which is doing such good work under Professor Teichmüller's direction. Illuminating Engineering Societies exist in the United States, Great Britain, Germany, Austria, Holland, Japan and Russia. In practically all the chief European countries lighting bureaux, with aims similar to those of the E.L.M.A. Lighting Service Bureau in this country, have been established. Throughout Europe and the United States demonstrations, popular lectures and courses for illuminating engineering are being developed. Readers will doubtless be interested in the account of the Philips Lighting Bureau in Brussels (p. 220) and the impressive Westinghouse Lighting Institute in New York (p. 222), described in this number. In the United States electric supply undertakings have for many years taken a leading part in this educational work. In Austria, Dr. Bausenwein mentions, the co-operation of the 30 leading undertakings has been secured. Conditions in this country are not yet so far advanced, but we hope and believe that it is only a matter of time before all the chief supply undertakings will be actively interested in illuminating engineering.

Mr. Atherton's paper contains some interesting data on the work of various lamp companies. Some singular differences are revealed. Thus it is stated that one company lists no fewer than 440 different types of lamps. Again, one firm with a total production of only 700,00 lamps lists 260 varieties, yet another with a production of 38,000,000 advertises only 130. Of 24 lamp companies investigated the largest does business in 64 countries. One company producing only 700,000 lamps sells in 49 different countries; yet another with a production of 38,000,000 sells in only three. Such differences may well help to explain differences in prices of lamps. Another influential factor is variation in supply voltage. This country is notoriously unfortunate in this respect. It is encouraging to observe that there is now a decided tendency towards the adoption of either 115 or 230 volts as the operating pressure on which lamps are sold.

In many other respects conditions in Europe differ from those in America. In that country the problem of introducing modern lighting methods in ancient buildings is less often encountered and the tendency to perpetuate designs based on past traditions is less in evidence than is usually the case in Europe. Similarly, the development of street lighting and the application of luminous traffic control devices are profoundly influenced by the narrow and crooked thoroughfares in many old European cities, so different from the uniform broad straight thoroughfares, intersecting at right angles, which are characteristic of towns of recent growth. There is a general recognition of the need for standardization, a question which is naturally far more difficult in old-established countries, where the lighting industry has grown up gradually, than in America and Japan.

Most interesting of all is the comparison of the mental outlook of different nations. This, we may well believe, is affected in some measure by climatic conditions. The principal centres of population in Europe are relatively far north. For half of the year mankind in these regions receives too much daylight, rendering it difficult for some persons to get sufficient sleep; in the other half of the year darkness is so persistent as to exercise a distinctly depressing effect. Apart from this, each country has its own attitude towards appeals for better lighting. Mr Atherton sums up his impressions as follows:—

"Dr. Bausenwein, in his paper on lighting-

* *Trans. Ill. Eng. Soc.* U.S.A., July, 1929.
† *Journal of the Western Society of Engineers,* Vol. XXXIV, No. 8, August, 1929.

promotion in Austria, paints a picture of a happy care-free pleasure-loving people who are entirely different from the people of many other nations and who have an entirely characteristic attitude of receptiveness to lighting-promotion activities. The very successful commercial campaigns in England would probably not be equally successful elsewhere; the scientific approach to the problem of lighting which convinces the German audiences and the primary appeal to art which is making a new epoch in illumination in France, etc.—each of these modifications of the method of promoting better lighting practice indicates a different attitude of receptiveness that is being more and more understood and met."

Mr. S. E. Doane, in his address before the Western Society of Engineers, likewise gave an amusing account of these differences. In London he suggested, when visits to the demonstration centre were being arranged, that the first thing was to get the engineering societies in. " I noticed that I hadn't said the right thing, and after a minute or two I said: 'Did you have some other suggestion?' 'Why, yes,' they said, 'we think first we should get the Home Office in' . . . and it turned out that the Home Office was the British Government." In France, on the other hand, he found that there was a strong feeling that the first thing was to get architects interested, whereas in Berlin they wanted first to go after the Chambers of Commerce, and in Italy—where perhaps the school teacher occupies a higher position than in any other land—to secure the sympathy of the *intelligentsia*.

In emphasizing the importance of demonstrations Mr. Doane quoted an old Chinese proverb: " One look is worth a thousand words." This is doubtless profoundly true, though the nature of the glance, and the directions in which it may most profitably be cast, vary in different countries.

The Holiday Season

THE month that has just passed is, by general consent, a holiday period. Illuminating engineers, like others, have been enjoying a little relaxation, trusting to the sun to carry on with his branch of illuminating engineering. The annual holiday is now a fixed and settled institution. This was not so in an earlier age. Dean Inge, in one of his stimulating contributions to the *Evening Standard*, has recalled the impression of a past age that play should be discouraged, even in children. It was sagely remarked that if a child does not play when he is a child he will be less likely to do so when he is a man. The idea does not seem to have been entertained that it might be justifiable and even expedient that grown-up people should know how to play! Dr Johnson, indeed, is credited with the saying that a man is never so innocently occupied as when he is making money. This may or may not be true, but periods of abstention from money-making may be both innocent in themselves and contributory to better work afterwards.

The achievements of science have enabled us to do much more work within a given period than was possible in the past, and have earned for us periods of relaxation. The teachings of science, as conveyed by the Industrial Fatigue Research Board, have shown the benefit of recuperative pauses, and have established the fact that it is possible to labour for longer periods and yet accomplish less!

The best work is done by those who regard it as their play—the most engrossing and permanent of their pastimes, from which, nevertheless, it is expedient to abstain occasionally, in order that one may return to it with greater zest.

The Report of the Chief Inspector of Factories for 1928

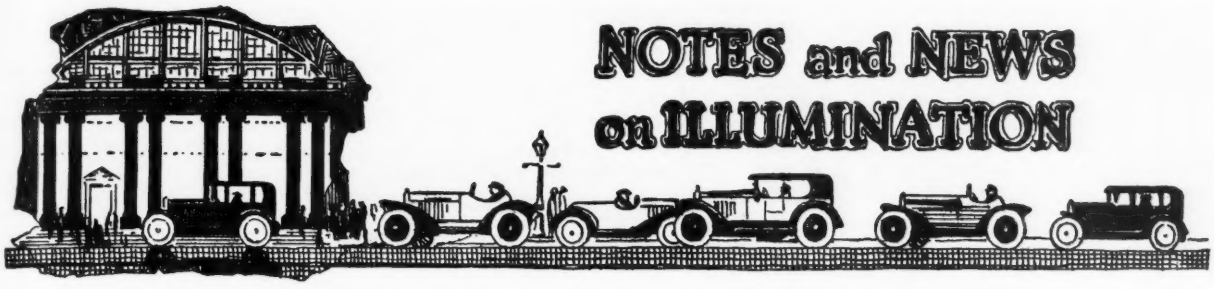
THE Report of the Chief Inspector of Factories for 1928, like that for the preceding year, draws attention to several important tendencies in industry. There is a continuing tendency for new industries to establish themselves in the south of England, especially in the vicinity of London. The small local workshops continue to disappear, and operations are being increasingly carried on in large factories, where mass production is possible.

The General Report contains interesting sections on such matters as safety, dangerous trades, welfare, etc., and the usual reports of the senior medical, electrical and engineering inspectors are included. A special section is devoted to the Home Office Industrial Museum, which has thoroughly justified its existence and continues to do excellent work. It is mentioned that over 8,000 visitors, of very diverse occupations and many of them hailing from distant lands, visited the museum last year. Encouraging testimonies to its educational value are quoted—one of the most interesting of these being from a firm which in the past had shown a marked reluctance to comply with the Factory Acts, but now professes complete conversion! It is mentioned that the Illuminating Engineering Society has held several meetings in the lecture theatre of the museum, adjacent to which there is a useful exhibit illustrating fundamental principles of good illumination.

The Home Office Factory Department continues to take an active interest in illumination. Mr. D. R. Wilson has continued to represent the Home Office on the B.E.S.A. Sectional Committee on Illumination and on the National Illumination Committee. Mr. Lowe has acted as a Home Office representative on one of the sub-committees of the Illumination Research Committee, which is dealing with the question of dock lighting.

The series of lighting tests recommended by the above committee are being continued. Miss Coombes reports instances of inadequate lighting in the Sheffield district, due in many cases to conservative outlook, and comments on the special problem of avoiding glare from the polished surfaces of articles manufactured in the cutlery trade. Mr. Shopland, who has been conducting investigations relating to processes in the engineering, motor trade, boots, needles, silk ribbons and watch trades, likewise comments on the low order of illumination still prevailing in many factories, illuminations below 5 foot-candles being recorded in cases where work had to be accurately performed to within one-thousandth of an inch or less. The winding, warping and weaving processes in the silk ribbon industry are very badly illuminated, a high percentage of readings being below 2 foot-candles, and in many instances no light sources were provided at the backs of the looms. Similar experience is quoted by other inspectors, and at least one fatality in a mill yard was attributed to inadequate lighting.

Notwithstanding these bad examples there are signs of steady improvement, and many of the newer factories are now equipped with excellent systems of lighting. This improvement, we believe, is in no small measure due to the sympathetic interest in illumination taken by factory inspectors and the constant educational influence which they exercise.



The International Illumination Congress 1931

Readers will recall the announcement that the next International Illumination Congress, in 1931, is to be held in this country. The British National Committee, in co-operation with the Illuminating Engineering Society, will be responsible for this important event. The Congress will be followed by the technical meetings of the I.C.I. Whilst the exact arrangements are still under discussion we understand that in all probability the Congress will be combined with a tour of places of interest in England and Scotland during the period September 3rd–13th, after which the technical meetings of the Commission will be held in Cambridge during September 13th–19th. The suggestion of holding meetings in the various provincial cities as well as London seems a happy one, which should do much to stimulate interest in illumination in this country. A number of committees have already been set up and are investigating details. Meantime we understand that Colonel C. H. Silvester Evans (c/o The Illuminating Engineering Society, 32, Victoria Street, London, S.W.1), has kindly consented to act as Hon. General Secretary. Communications on technical matters which concern the I.C.I., however, should still be made *via* Mr. W. S. Stiles, General Secretary of the I.C.I., and those relating to the National Committee *via* Mr. H. Buckley, Hon. Secretary of the National Illumination Committee of Great Britain, both of whom are located at the National Physical Laboratory, Teddington.

Association of Public Lighting Engineers

SIXTH ANNUAL CONFERENCE AND EXHIBITION.

The final programme of the sixth annual conference of the Association of Public Lighting Engineers, which is to be held in Bournemouth during September 9th to 12th, is now available. The proceedings will be opened by a reception at the Town Hall by the Mayor of Bournemouth on the evening of September 9th. On Tuesday the Presidential Address will be delivered, following which there will be papers on "Lighting and Rating," by Ex-Baillie James MacDougall (Glasgow), and "Compromise in the Use of Illuminants for Public Lighting," by Mr. C. H. Woodward, Lighting Superintendent of Bournemouth. (This last is certainly an intriguing title.) Interposed between these two papers there will be a luncheon in the Town Hall, where visitors will be the guests of the Chairman and Directors of the Bournemouth Gas and Water Company. On the Wednesday there are two more contributions, by Messrs. J. F. Colquhoun and E. J. Stewart, on "American Practice in Public Lighting," and by Mr. J. S. Dow on "Private Lighting as a Supplement to Public Lighting. The afternoon of this day will be devoted to an exhibition of public lighting appliances in the Town Hall, where the Association Dinner will be held in the evening. On the Thursday (September 12th) there will be opportunities for excursions to the Isle of Wight, the New Forest, Corfe Castle, etc., of which members will doubtless make good use.

Industrial Lighting

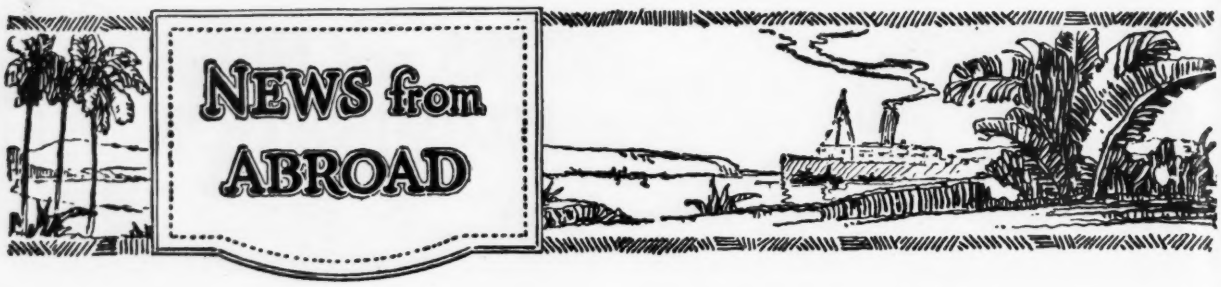
We are glad to see that a paper by Messrs. L. B. W. Jolley and G. H. Wilson on the above subject figured in the proceedings at the Fortieth Congress of the Royal Sanitary Institute, held in Sheffield during July 13th to 20th. The influence which medical men and sanitary inspectors exercise on the public mind is very great, and fuller use should be made of the opportunities presented at annual congresses of bringing the claims of good lighting before their notice. In their paper the authors emphasized the need for help from this quarter. They wisely confined themselves mainly to fundamental principles, such as the provision of adequate illumination, the avoidance of glare and the necessity for cleanliness and frequent regular maintenance, and their discussion of factory lighting brought out many points which deserve to be better appreciated by those concerned with public health.

The New "Underground" Building

It is seldom that a new building attracts so much public attention as that now being constructed for Underground Railways Ltd. at St. James's Park. In our daily journey past the building we rarely fail to find an interested group. This curiosity has doubtless been kindled largely by the publicity given to the allegorical figures of "Day" and "Night" (regarding which we decline to be drawn into controversy!), but there is also something in the original architectural scheme which appeals to the popular imagination. The building-up of the terraces makes an imposing skyline, and the T-shaped section of the upper part of the building, besides its obvious advantage from the standpoint of access of daylight, produces a striking visual effect. Incidentally this arrangement seems to be a happy one in facilitating floodlighting, as it affords sites for projectors at a considerable distance from the two vertical walls. The white surface of the building is also favourable to this treatment, and it will be interesting to see what steps are taken in the autumn.

Kinema Studio Lighting

In the course of a chat with an engineer closely interested in the equipment of kinema studios we were recently given to understand that the introduction of the "talkie" film is bringing about a revolution in lighting methods. High candle-power incandescent lamps are now being utilized in increasing numbers. The introduction of panchromatic films had already given an impetus to the use of these lamps in place of the more highly actinic types, but an even more important point is the necessity for absence of extraneous noises. The problem of accurately recording sounds, music and speech is already sufficiently difficult, but it becomes impossible if casual noises, which are apt to be magnified by the microphone, cannot be excluded. Thus the hissing noise inseparable from the use of open arcs, even though slight in the best types, is leading to the exclusion of these sources from the modern kinema studio. Gasfilled incandescent lamps up to 5 kw. capacity are now being used on account of their noiselessness and ease of manipulation, and some highly ingenious types of floodlighting projectors for studio work have been designed. Lamps of exceptionally high candle-power, however, have to be used with some care. Another difficulty is the tendency to overheating of studios, owing to the higher consumption of energy necessary to obtain a given illumination. The heat generated in some projectors is considerable, and lamps with bulbs of specially resistant glass are now being supplied. If a completely noiseless open arc could be devised we should doubtless see a reversion to this type of lamp. Experiments in this direction are now proceeding, and it is probable that the evolution of such an arc is only a matter of time.



German Illuminating Engineering Society

SEVENTEENTH ANNUAL CONFERENCE.

We notice that the seventeenth annual conference of the German Illuminating Engineering Society is to take place in Vienna during September 12th to 15th. The meeting is to be followed by a visit to Budapest, so that a good opportunity will be afforded for the fraternization of lighting experts in Germany and Austria. It is the usual practice of the Illuminating Engineering Society in Germany to devote these annual conferences to special subjects, a series of papers being presented on different aspects. On this occasion the majority of the papers will deal with glass in relation to illuminating engineering. Dr. H. Schonborn, Dr. L. Bloch and Dr. H. Fruhling will deal with diffusing glasses, and Dr. F. K. v. Goler with the application of the three-colour theory to coloured glasses. Herr Dziobek's contribution is devoted to tests of glow-lamps with bulbs translucent to ultra-violet energy, and Dr. W. Bertelsmann with glasses for use with gas lighting. A further paper by Mrs. M. Schirmann on the influence of gases on glass should prove instructive.

Light's Golden Jubilee

As readers are aware, the United States has been actively celebrating the centenary of Edison's work on the incandescent lamp under the above title. A feature of these celebrations has been the intensive application of spectacular lighting, of which many striking examples are illustrated in *The Electrical World* (August 20th). The issue contains a coloured inset showing the effects of floodlighting with amber light, and it is evident that coloured floodlighting is becoming quite usual in America. A particularly effective illustration is that showing the appearance by night of the Paramount Building, New York, the upper floors of which gradually narrow to an apex. There is also an interesting article by Mr. G. R. Lawall on the designing of faces of buildings with a view to their illumination by night, and other minor decorative effects, such as the incorporation of miniature lamps in toy balloons and jewelled medallions, are discussed.

Floodlighting on the Indian Railways

We have been favoured by Mr. H. J. Mulleneux, Assistant Electrical Engineer to the G.I.P. Railway, with a copy of a technical paper by him reviewing the application of floodlighting in work on the Indian Railways. Whilst much has been written on the use of floodlighting for decorative and spectacular purposes, less information is available regarding its application to railway and constructional work. The author points out that in lighting for purposes of advertisement we have usually to deal with extensive vertical surfaces. In constructional work, however, the area is almost invariably a horizontal one, and there are numerous factors which render its application more difficult. Assuming that a large horizontal area, such as a railway yard, is to be lighted, the author distinguishes four main methods of lighting: (1) Unit or point lighting by units mounted on poles 30 to 35 ft. from the ground; (2) catenary or suspension lighting by means of sources of relatively low intensity suspended from span wires; (3) tower lighting, with clusters of lights of high candle-power mounted on towers at heights of 100 to 150 ft. above the ground; and (4) projector lighting, by projectors directing a beam of light from heights of 75 to 100 ft. above the ground. Of these systems the first is most commonly adopted in India; (2) and (3) have been tried in isolated cases, and (4) is still in the experimental stage. The paper contains a useful review of the advantages of these various systems, and deals with various points of importance to railwaymen, such as the avoidance of glare and the obscuring effect of smoke clouds from locomotives. We hope to give a fuller account of the author's conclusions in a later issue.

Public Lighting at Nimes

According to *The Revue Générale de l'Electricité*, the city of Nimes has recently been making substantial improvements in its lighting system. In the main streets central suspension is being adopted. The units are of the reflector type, and are light and robust in character, and lamps taking from 250 to 750 watts are installed, according to the importance of the street. These units are mounted 35 to 40 metres apart and nine metres above the surface of the roadway. Some photographs of the Boulevard Victor-Hugo suggest that bright illumination has been obtained, and the small units are inconspicuous in the daytime. The average illumination is stated to be 5.8 lux (approximately half a foot-candle) and the minimum between the lighting units is given as 2 lux (approximately 0.2 foot-candle). In this southern city, which is exposed to sudden storms and to the "mistral," rigidity and robustness of the lighting units are of great importance. In the severe storm of February, 1928, buildings were damaged, trees torn up and telephone lines put out of action, but it is stated that the municipal lighting of Nimes continued to function satisfactorily.

The Lighting of Showcases

An article by Monsieur V. N. Siegel in *Lux* discusses an interesting development on the Continent—the tendency towards accentuating certain objects in showcases by means of light. The customary practice, which may be said to be the basis of modern show-window lighting, is to flood the entire display with light from concealed sources. It has, however, already become not unusual to single out special objects in the window by means of "spotlights," to which coloured gelatines, sometimes furnished with a mechanism to give continuously varying colour, are often attached. M. Siegel, however, in dealing with showcases, goes a step further. The extra illumination by spotlights can only confer a certain measure of prominence. They may be rendered yet more distinctive by means of concealed local lamps, either embodied in the design or ingeniously screened by metal casing, adjacent to the object displayed. Some original and effective designs, in which tubular lamps play a leading part, are illustrated in the original article.

The World's Consumption of Carbide

According to *The Journal de l'Acetylene*, the world's consumption of carbide amounted to 578,000 tons in 1928, as compared with 339,000 tons in 1913. The greatest increases in consumption have been in Germany, Belgium, Denmark, Japan, China and Africa. In certain countries acetylene lighting has almost disappeared, but in others material progress, especially in the use of portable lamps, is recorded. One interesting application of such lamps is on the French railway systems, where upwards of 50,000 are now in use.

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—Data for Contractors—Hints to Consumers

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society; and is based on outside contributions.)

Modern Tendencies in Domestic Lighting

By R. WALDO MAITLAND, Architect
(E.L.M.A. Lighting Service Bureau.)

THE simplicity of the modern house, compared with that of twenty years ago, has brought about a distinct change in the design and style of furnishings, and since lighting cannot be separated from the general furnishing of apartments it has found a fresh means of expression to accord with the modern movement. As a result, in the field of residential lighting we find touches of an entirely new system of illumination which makes full use of modern progress in both lamps and lighting material.

The more lavish use of light in the home of to-day has been brought about, in large measure, by the steady reduction both in the price of lamps and in the cost of electrical energy for lighting purposes. The modern tendency is to introduce into domestic interiors a variety of luminous sources, some of which may provide only a decorative effect, and, as a rule, most of these new lighting fittings have a very high percentage of glass in their composition. Commonly, the glass is obscured by acid etching or sandblasting, while at times sheets of opal or textured glass are used as the light-diffusing medium.

A few months ago, in the Grand Palais in Paris, an exhibition was held dealing exclusively with the decoration of domestic interiors, and it was noticeable that the lighting element was made an essential part in the general design, whether taking the form of applied fittings or of fittings actually built into the structure of the room, and it was also noticeable that this lighting for effect was always supplementary to the general lighting provided by other means. One of the features of this new lighting movement is the use of ceiling fittings introduced in the form of flush or projecting panels fixed in such a way as to enable easy access to the interior both for lamp renewals and cleaning of the glassware. These ceiling panels themselves are usually of opal or some other obscured glass, but occasionally such materials as parchment are employed.

Indirect cornice lighting is another method of general illumination for the larger type of domestic interior, but care must be taken that enough depth is given to the cornice for the housing of the lamps, and also that it is low enough on the wall to enable an even illumination to be obtained on the ceiling. Forms of decorative lighting for the modern home are very numerous, and should be chosen with considerable forethought, since they must harmonize with the general character of the room, otherwise the whole spirit of modern lighting is lost.

The floor standard illustrated in Fig. 1 possesses a distinct character of its own, and would lend itself quite well to use in many modern homes, since it has the essential simplicity of line, together with a functional significance which accords with modern decorative art. The illuminated mirror shown in the second illustration is an interesting example of the accentuation of familiar

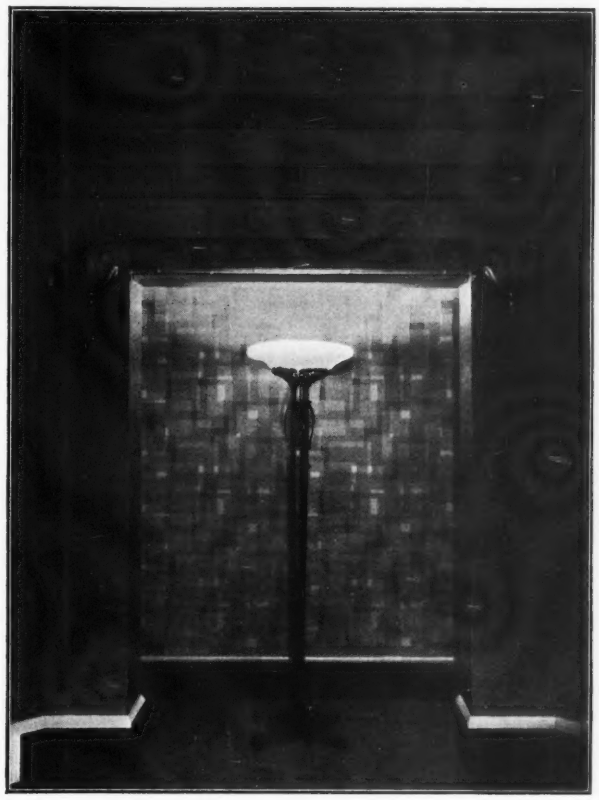


FIG. 1.—A distinctive type of Floor Standard.

furnishings by the provision of a luminous effect, while, in addition, the functional aspect is not lost sight of, as the lighted panels at the side of the mirror actually prove very satisfactory for enabling the mirror to be used for its ordinary purpose.

The third illustration indicates an application of electric light for rendering a library or shelves for the display of *objets d'art* more interesting and attractive. In this example the lighting of the shelves is achieved by lamps concealed behind small diffusing panels, some of which are in the vertical plane and others in the horizontal.

In addition to this lighting, it will be noticed that the large vases, although not actually luminous in themselves, add considerable life to the effect by the reflection of high lights from the various light sources, and such details should not be overlooked in choosing the furnishings for an interior lighted in accordance with modern conceptions.

Many houses to-day are not in the true sense "modern" as regards the furniture of furnishings, but the general character is simple and these modern systems of lighting will usually blend quite happily. In lighting of this kind due consideration should always be given to the type of light required; both from the practical and decorative aspect, and in designing the room, lighting fittings should be selected in such a way that a suitable balance is established between utility and beauty.

FIG. 2.—An Illuminated Mirror, with lighted panels at side.

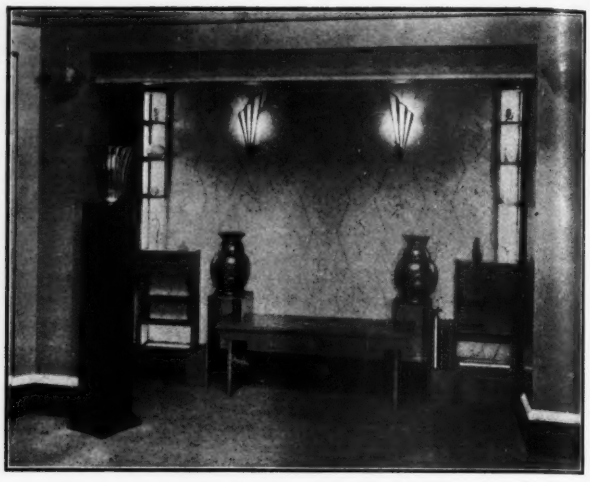


FIG. 3.—The Lighting of Shelves in a library by means of lamps concealed behind diffusing panels.

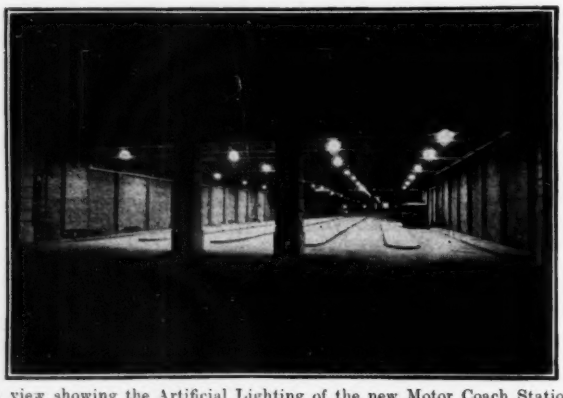
Lighting Great Britain's Largest Motor Coach Station

AN important step in the progress of motor coach operation has been made by the construction of a huge station at Kennington Oval expressly for the purpose of parking motor coaches whilst in London, and providing all the necessary facilities for intending passengers.

The station was designed for Southern Coastal Services Ltd., by Mr. Edw. W. Wallis, L.R.I.B.A., and will be available for the use of motor coach owners desiring parking facilities in the Metropolitan Area. There is sufficient parking space for more than 250 coaches, in addition to a number of waiting rooms, buffet bars, booking offices, etc.

As the station will remain open day and night an efficient lighting installation was essential, and Philips "N.R." type industrial reflectors with "Argenta" lamps were decided upon, the work being carried out by Messrs. Pruden & Pope. The result has proved entirely satisfactory, the whole station being flooded with an evenly diffused light entirely free from glare. A good idea of the appearance by artificial light will be gathered from the accompanying illustration.

Fifty-four "N.R." reflectors with 300-watt "Argenta" lamps were installed in four rows, more closely spaced over the loading platforms than the remainder of the garage, resulting in 8-10 foot-candles over the platforms and 4–5 foot-candles elsewhere.



A view showing the Artificial Lighting of the new Motor Coach Station at Kennington Oval.

Lighting Demonstrations at Torquay

A FEATURE of the I.M.E.A. Convention, recently held at Torquay, was a series of special lighting demonstrations arranged by leading firms. We reproduce a night view of the Town Hall, which, together with St. John's Church, the Pavilion, and other buildings, was floodlighted by the

The Torquay Town Hall. Floodlights during the I.M.E.A. Convention.

General Electric Co. Ltd. The British Thomson-Houston Co. Ltd. were responsible for the colour floodlighting of the Royal Terrace Gardens, the Ladies' Bathing Cove and the Grand Hotel, and for a series of special demonstrations of shop-window lighting. These and other firms participated in the displays at the exhibition, where the E.L.M.A. Lighting Service Bureau showed a series of panels illustrating modern lamps, and the lighting of homes, schools, factories, etc., for use in electricity showroom windows. Other E.L.M.A. exhibits included a novel form of luminous sign reading, "I.M.E.A. Exhibition," featuring letters built up of opal plates, and a number of special lighting fittings (including two luminous columns at each side of the entrance doorway on the ground floor).

Lighting demonstrations of this kind are becoming a usual feature at conventions, which afford excellent opportunities of stimulating local interest in illumination.

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The Activities of the Philips Lighting Service Bureau in Belgium

IT is always interesting to hear of educational work in connection with illuminating engineering in other lands, and we are indebted to Mr. J. B. Vink, an esteemed corresponding member of the British Illuminating Engineering Society in Belgium, for the following account of the activities of the Philips Lighting Service Bureau in that country.

The Lighting Service Bureau in Brussels serves as a centre of educational effort throughout Belgium. Its programme resembles that carried out so effectively by the Lighting Service Bureau in London, the primary aim being to educate people in Belgium in the principles of good lighting. In Fig. 1 we have a pleasing view of the ante-room. On entering visitors have before them a fresco, encircling the upper part of the room, showing, in a simple way, the various stages of incandescent lamp manufacture. The Bureau is equipped with a demonstration room, where various methods of lighting can be demonstrated. This room is equipped with typical lighting units. Direct, indirect and semi-indirect lighting can be shown in succession, the effect of a few high-candle-power units may be compared with a large number of sources of smaller intensity, the illumination being meanwhile maintained at the same value.

Other demonstrations include contrasts of effects from bare and opal (Argenta) lamps, emphasizing the soft shadows obtained with the latter and the comparative absence of troublesome direct reflections. Simple demonstrations of this kind are followed by practical applications. These are illustrated mainly in a series of model rooms equipped to represent a classroom, shop or workshop, in which some good and bad methods of lighting may be contrasted. Some of these exhibits are illustrated in Figs. 4 to 9. A special series of model rooms relating to domestic lighting, and comprising kitchen, dining room, smoking room, bedroom, drawing room and bathroom is available, and many different lighting systems can thus be shown. The stage of the demonstration room is mainly occupied by a model shop window where comparisons of good and bad methods of lighting, colour effects, etc., may be exhibited.

Lectures and demonstrations, both technical and popular, are given before different types of people. Thus engineers and architects can be shown the influence of deposits of dust on the reflecting power of walls and ceilings, and also the effect of the colour of surroundings on the available illumination.

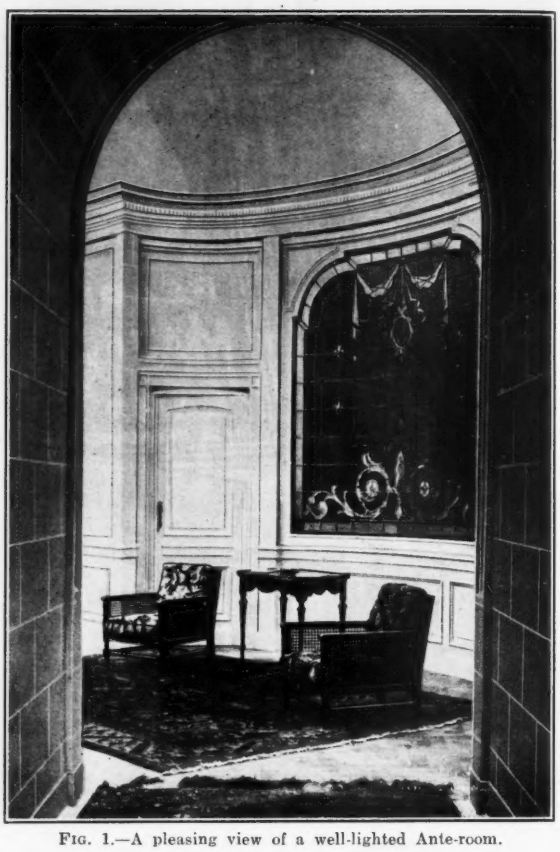

FIG. 1.—A pleasing view of a well-lighted Ante-room.

During 1926 to 1928 414 special lectures, given mainly to professional associations representing electrical engineers, doctors, architects, etc., were arranged. During this period there was a total attendance of 23,000. A special feature is made of lectures to school children. This lecture usually consists of a brief explanation of the main principles of good lighting, which is illustrated by demonstrations of lighting effects, and may be followed by a film showing the manufacture of lamps in the Philips works at Eindhoven. School children, accompanied by their teachers,

FIG. 2.—An adult audience in the Demonstration Room.

FIG. 3.—A group of school children receiving elementary instruction in the principles of good illumination.

FIG. 4.—Industrial Lighting. A bad example. The exposed lamp illuminates the work inefficiently, and causes glare in the eyes of the operator.

FIG. 5.—Industrial Lighting. A better method. The lathe is illuminated by well-screened local units, supplemented by efficient general lighting.

have shown great interest in these lectures. During 1926–28 as many as 16,500 school children received elementary instruction in illumination in the manner indicated above.

The importance of this branch of educational work can scarcely be overestimated. A child who has been shown the difference between good and bad lighting will remember this throughout his lifetime, and will ever afterwards act as an advocate of good illumination.

Another special branch of the activities of the Bureau consists of lighting consultations, either with visitors who bring to the office plans of buildings to be lighted or by correspondence. On request, lighting experts will, in the most important cases, visit the building and collect all the needful information. It is found that nearly all new institutions and factories approach the specialists of the Philips Lighting Service Bureau for aid in this way.

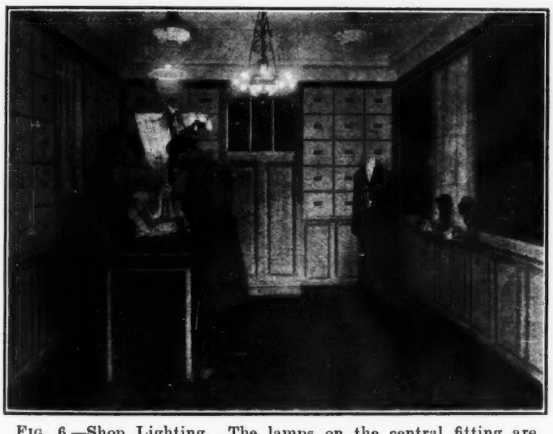

FIG. 6.—Shop Lighting. The lamps on the central fitting are liable to cast a shadow from the customer's body on the goods which he is examining.

FIG. 7.—Shop Lighting. The well-diffused light from this enclosed unit reaches all parts of the room, and troublesome shadows are avoided.

Apart from these popular lectures and demonstrations much work has been done with the object of creating a number of specialists in lighting amongst electrical engineers. Detailed courses are given to electricians and engineering students. These courses of instruction are broad in scope, the elements of physics, the physiology of the eye, explanations of units adopted in connection with illumination, etc., being included, as well as lectures on such subjects as the lighting of homes, factories, streets, theatres, etc.

Finally, the Bureau is now undertaking a considerable amount of publicity in favour of better lighting. The work consists mainly in two parts, technical booklets and popular articles in the press. The former are found to be of great service to electricians, and the latter have done much to bring about general appreciation of the principles of good lighting.

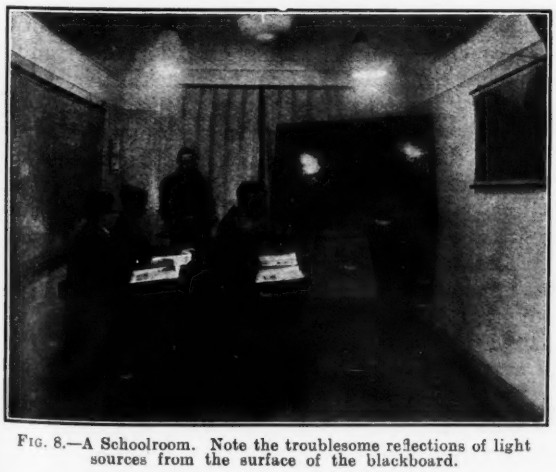

FIG. 8.—A Schoolroom. Note the troublesome reflections of light sources from the surface of the blackboard.

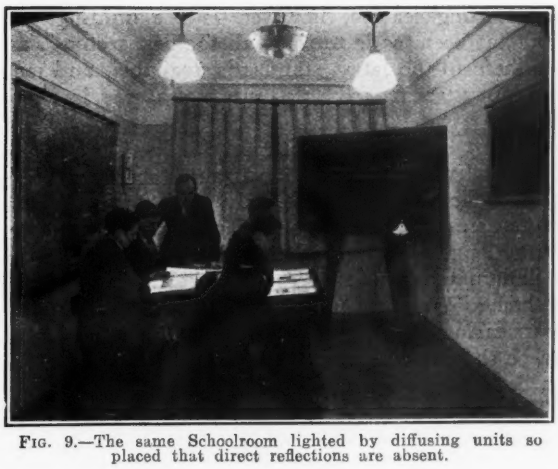

FIG. 9.—The same Schoolroom lighted by diffusing units so placed that direct reflections are absent.

The Westinghouse Lighting Institute in New York

A " CITY of Light " has recently appeared in the heart of New York City—the new Westinghouse Lighting Institute, which occupies the entire seventh floor of the Grand Central Palace. An account of this institute recently appeared in *The Electrical World*, from which the general plan illustrated in Fig. 1 is taken, and we are indebted to the director, Mr. Ralph Neumuller, for some further particulars, and for the interesting photographs which appear in Figs. 2 to 5.

The purpose of this creation of the Westinghouse Lamp Company is to illustrate what good lighting is in all its phases. Hence everything in this " City of Light " has been made as true to life as possible. The stores are stocked with appropriate merchandise, the show windows are regularly trimmed by experts from leading departmental stores, the model home is furnished on up-to-date lines and the factory contains machines of many different types. Amongst subjects too large to be presented in their entirety may be mentioned an airport, a railway system and a modern office building. These are reproduced in model form. The leading feature, however, is the lighting. An effort has been made to show all the best methods and to adhere to the latest standards available, and much originality as regards decorative features has been shown.

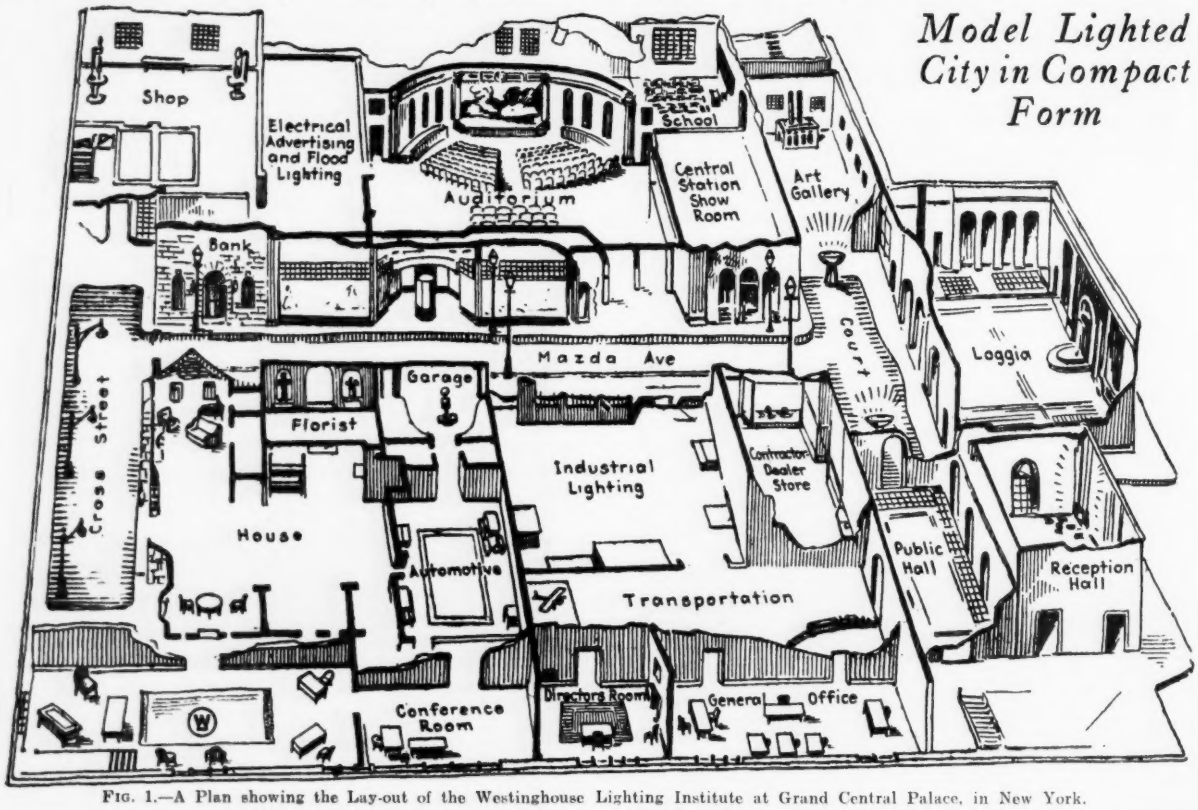

FIG. 1.—A Plan showing the Lay-out of the Westinghouse Lighting Institute at Grand Central Palace, in New York.

In many cases the exhibit can be lighted in a number of alternative ways, or with varying degrees of illumination. This applies particularly to what is perhaps the most interesting item—the " Mazda Avenue," a street 180 ft. long, and a cross-street 85 ft. long, which can be illuminated with 20 degrees of intensity. Similarly the home is equipped with automatically appearing and disappearing fixtures, so that a wide variety of styles can be shown, and most of the machines in the factory can be lighted by several different methods.

The institute thus serves as a most comprehensive and instructive exhibit. It should also be useful as a practical lighting laboratory, where experiments in many fields of lighting may be tried out. Thus in the model theatre provided managers can work out novel schemes with the aid of the highly versatile switchboard. Public lighting engineers will likewise be able to use Mazda Avenue in the solution of their lighting problems, and police officials can try out the latest forms of luminous traffic signals.

Mazda Avenue, which is 180 ft. long and 20 ft. wide, is illustrated in Fig. 2. Up and down the street on either side are illuminated store fronts, window displays and illuminated signs in great variety. Along the length of the street are seen a bank, a department store, a florist's shop, a theatre, an electrical store, a garage, a modern American home in early Colonial style of architecture, and other full-sized buildings. The street-lighting units, controlled from either side of the street, are of the decorative type, the posts having the appearance of having been fashioned from a single piece of granite. The connected cross-street provides an opportunity of demonstrating the use of traffic-control signals. In the early Colonial home every effort has been made to illuminate the various rooms in a distinctive way—a feature being the special lighting of the pleasing bathroom with built-in bath. All types of domestic lighting units are shown, and in one room a section of the wall is removable in order to show all the latest wiring devices. The loggia, illustrated in Fig. 5, offers opportunities for skilful concealed lighting. A feature is the colour-illuminated fountain, similar in design to that executed by the company for the International Exhibition in Barcelona, whilst in alcoves on either side of the loggia there are shown in miniature the Endless Caverns of Virginia and the Liberty Bell.

The transportation room, 20 ft. by 66 ft., is a novel exhibit. Cross-sections of street cars and motor buses enable various methods of lighting to be shown. Motor-

car headlights, locomotive headlights, and other forms of lights for vehicles are seen in operation. Other transportation problems are dealt with in miniature. Thus, pigmy electric trains run through cities, mountains and cascades, and a model aviation field (see Fig. 4) gives a vivid idea of what happens when day

FIG. 2.—" Mazda " Avenue, Broadway's " Great White Way," a full city street, 20 ft. wide and 180 ft. long. Shop-window lighting, street lighting and illuminated signs are all represented.

is replaced by night, and all the lighting appliances necessary for aerial traffic come into play. The art gallery, 20 ft. by 40 ft., embodies new lighting designs. Special lens fittings, flush with the surfaces of walls and ceiling, enable special architectural effects to be obtained. This system, equipped with artificial daylight, is also adopted for the lighting of operating tables in hospitals. In the lecture theatre (60 ft. by 46 ft.), which also serves for the demonstration of stage and cinema effects, novel methods of lighting are also used. Side-wall lighting in four colours is provided. There is overhead lighting from seven distinct circuits

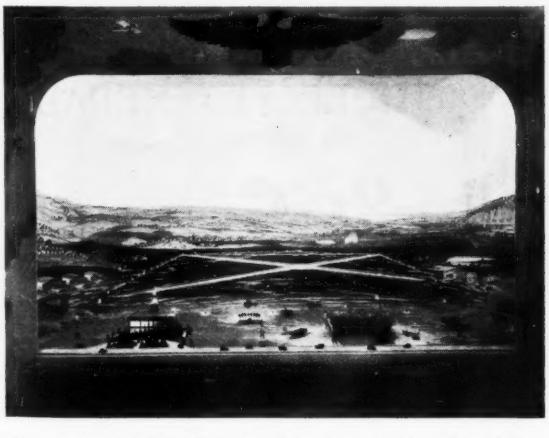

FIG. 4.—An Aviation Ground. Here again the transition from daylight to darkness is depicted. The lights of the airport appear, and the floodlighting of the landing-place reveals all details.

capable of furnishing up to 100 foot-candles The stage is well equipped for diversified lighting effects, and the dressing rooms would serve as a model to many actual theatres. The electrical advertising room is designed to show all the various applications of light for purposes of publicity, and a feature here is the scenic picture of Battery Park, illustrated in Fig. 3.

Amongst other exhibits may be mentioned the standard classroom, capable of taking 35 adults, which is intended to serve as a model to education authorities —all such matters as desk and blackboard lighting, absence of glare and troublesome shadows, etc., being carefully studied.

The directors' office is equipped with artificial sunlight windows, and, like the adjacent conference room, is finished in Italian style.

In the " Automotive Room " all the applications of light in the automobile industry are represented. Electric lighting systems for motor cars, headlights and

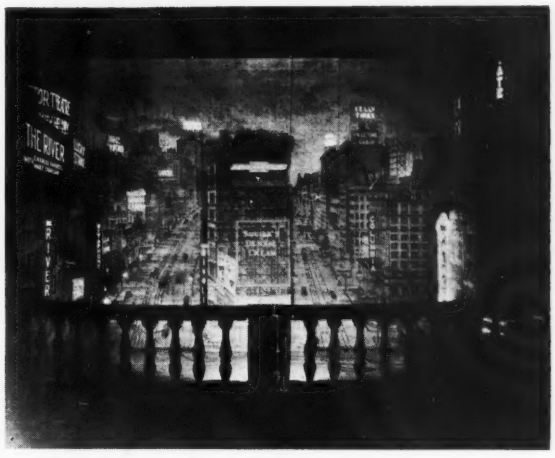

FIG. 3.—A 20-ft. Scenic Curtain, displaying a picture of Battery Park. The change in appearance as daylight fails is faithfully portrayed. As darkness falls lights appear, and every single sign or building visible from the window is depicted.

other vehicle lights are explained and demonstrated, and there is a model filling station with up-to-date show windows and tanks, where correct methods of lighting are shown. The equipment of the model bank is such as to suggest solidity, and the fittings are specially designed both to give the requisite illumination and to create the desired impressive effect. Needless to say the Central Station Display Room is of special interest to electrical engineers. This room is devoted to the display of electrical merchandise somewhat different from that usually displayed in electric stores. Here,

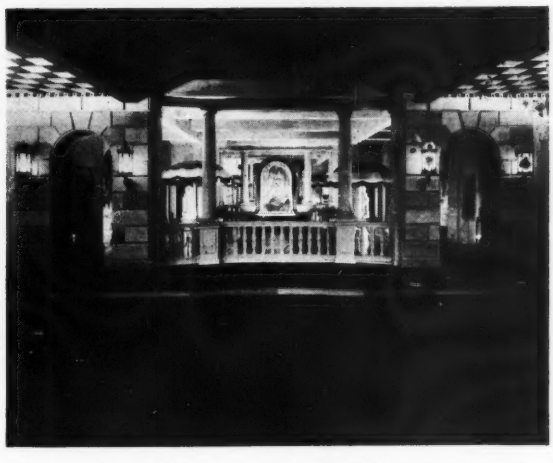

FIG. 5.—The Lighting of a Loggia—a restful porch or veranda. A feature is the skilful use of concealed lights and the illuminated fountain (similar to that built for the International Exhibition at Barcelona).

too, demonstrations of shop lighting are given and experts on lighting and display may be consulted.

The institute uses approximately 70 miles of wire, 800 switches, and over 4,600 sockets, and has a connected load of 750 kw. It comprises 15 different building interiors, 600 ft. of street front, and about 400 different types of room units are shown in operation.

The above description will serve to show the imposing scale on which this new Lighting Institute is conceived. It illustrates the great importance attached to demonstrations of lighting in the United States, in which manufacturers and supply undertakings alike participate.

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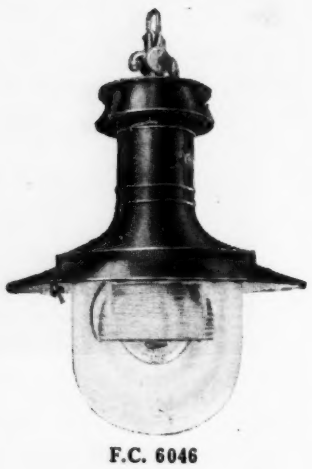

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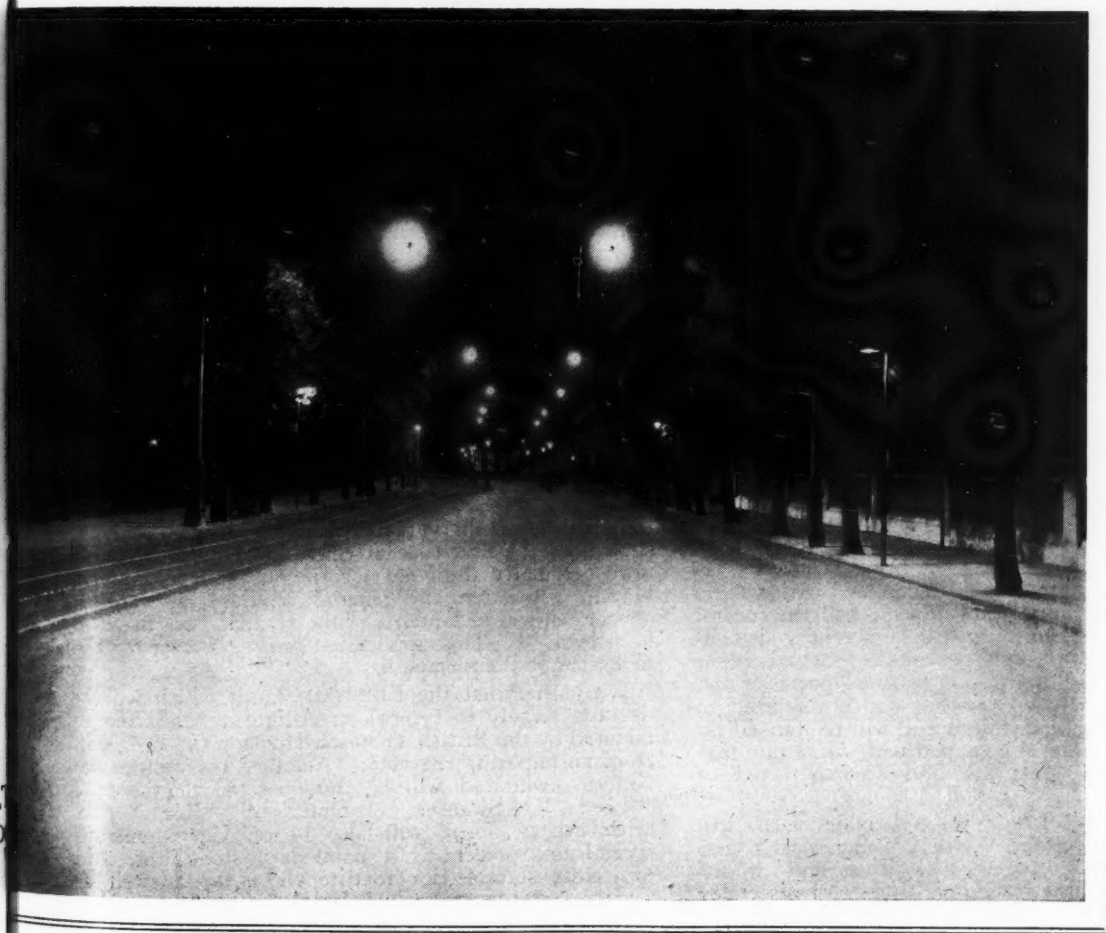
Saturday, June 29th, the first section of the new installation was switched by Sir Geo. W. Humphreys, K.B.E., Chief Engineer, L.C.C. Below is a roduction from an untouched night photograph.



Association of Public Lighting Engineers

Exhibition at Bournemouth

WE give on p. 215 some particulars of the programme of the sixth annual conference of the Association of Public Lighting Engineers, which is to be held in Bournemouth during September 9th to 12th.

A feature of this gathering, as in past years, will be the exhibit of lamps and lighting appliances used in public lighting, which will take place in the Town Hall. We are informed that the following firms will be exhibiting: The British Thomson-Houston Co. Ltd., The Bromford Tube Co., The Electric Street-Lighting Apparatus Co. Ltd., Edgar & Co., Engineering & Lighting Equipment Co. Ltd., Foster & Pullen Ltd., Gas Meter Co. Ltd., General Electric Co. Ltd., W. R. Gunning & Co., Horstmann Gear Co., Korting & Mathiesen Electrical Ltd., Holophane Ltd., Lighting Trades Ltd., Metro-Vick Supplies Ltd., Municipal Supplies Ltd., W. Parkinson & Co., Radiovosor Parent Ltd., Revo Electric Ltd., Siemens Electric Lamps & Supplies Ltd., W. Sugg & Co. Ltd., Venner Time Switches Ltd., Wardle Engineering Co. Ltd.

Not all the firms exhibiting have yet responded to our invitation to furnish particulars of their display, but we have received sufficient information to show that the exhibition should be quite as interesting as those in former years.

The leading firms in the electric-lighting industry are well represented. THE GENERAL ELECTRIC CO. LTD., which took an important part in the demonstrations at Sheffield last year, is staging a great variety of apparatus, some of which will be of a novel character, never having been shown outside the G.E.C. Research Laboratories. Of special interest is the promised street-lighting visualizing apparatus, which is designed to enable public lighting engineers to form an impression of the effect in practice of any arrangement of side lamps, centrally suspended units, etc. The model will enable nine different types of lighting, in six different streets, to be seen. Amongst street-lighting units to be shown may be mentioned a new small asymmetric refractor designed for use with 60, 100 or 150 watt lamps. This fitting is of the " non-ventilated " type, and special efforts have been made to diminish glare to a minimum. Another G.E.C. item is a non-ventilated lantern, which illustrates the gain in efficiency obtainable by total enclosure. Other exhibits will illustrate the manner in which street-lighting efficiency is impaired by allowing reflectors to become dirty (the life history of these exhibits being given), and the control of light by asymmetric units will be specially demonstrated. A series of enlargements of actual night photographs of installations in various parts of the country will be included on this stand, the front of which will be of striking design and will be flanked by decorative street lanterns equipped with white raindrop diffusing panelled glassware and various types of standards.

The exhibit of METRO-VICK SUPPLIES LTD. will include examples of the " Nile," " Spherical," and " Brighton " units, together with several works-lighting fittings of the focussing, angle and dispersion types suitable for factory and yard lighting. A selection of commercial-type Silverstone units will be on view, a feature being two types of fittings recently designed for hospital lighting. Met-Vick " flooding " projectors will also be included in the exhibit. These represent a distinct advance upon earlier models and furnish ample and evenly diffused illumination conjointly with high efficiency and mechanical strength.

MESSRS. SIEMENS ELECTRIC LAMPS AND SUPPLIES LTD. will show a range of fittings for street lighting and for the illumination of public halls, etc. Amongst the street-lighting fittings may be mentioned the "Silvalux" unit, designed for use with " Silvalux " opal gasfilled lamps. Even illumination and absence of glare are features of this fitting, the opal bulb considerably improving the distribution of light in a horizontal direction. The fitting utilizes a vitreous enamelled reflector of special curvature to assist the distribution of light at about 15° below the horizontal. Other units to be shown will include a range of totally enclosed fittings, such as the new " Ultralite " unit, with a glass canopy in place of a metal one, and the " Helilux " moulded-glass decorative units. A new fitting, the " Eralite," is designed to give illumination resembling natural diffused daylight. Other items include a flashing traffic signal, a direction indicator, K-Ray illumination cases for displaying notices, etc., outside public buildings and railway stations, floodlights for outside use, and a full range of Siemens electric lamps.

MESSRS. KORTING & MATHIESEN ELECTRICAL LTD. will have a good display of the familiar " Mirrorlite," " Throlite " and " Farlight " units, which utilize prismatic reflectors or refractors, and some of the " O " series of " glowband " lanterns, a feature of which is the use of a band of diffusing material, so that an extensive curve of light distribution is combined with minimum glare. Numerous other floodlighting, hospital and other special units will be on view, and also a 15-amp. " Dia " enclosed-flame arc (which is now constructed for alternating current in sizes up to 40 amps.).

MESSRS. HOLOPHANE LTD. are exhibiting a complete range of their directional prismatic refractors for street lighting, which is now extremely complete. The familiar bowl reflectors are now available in six types, symmetrical, asymmetrical, 2-way non-axial, 2-way axial, 3-way non-axial, and 4-way axial. Dome refractors have also been further developed, and 2-way and asymmetrical types are now available, whilst band-type refractors are now made in the symmetrical and 2-way axial types. A new ornamental type of unit for park and promenade lighting has been developed. A highly ingenious and novel device, which should be of special interest, is the Holophane " Spot-O-lite " unit, based on a new optical system, and enabling very varied effects to be obtained. This has recently been applied to the lighting of officers on point duty, and should also prove useful for the lighting of public clocks, notices, etc. A particularly interesting development, which will likewise be on view at the Holophane stand (No. 3), is the series of prismatic plates adaptable to gas lanterns, shown for the first time at Sheffield last year. These were originally designed for the square-type lantern, but, in response to the demand, similar glassware for cluster burners in lanterns of the circular type has also been evolved. This application will be shown for the first time at Bournemouth.

We gather that the EDISWAN stand, which will be devoted largely to typical street-lighting units manufactured by the British Thomson-Houston Co. Ltd., will be of an imposing character. Amongst the well-known lanterns exhibited will be those of the " London," " Leeds," " Swansea," " Durham," " Kent," and other types. There will also be on view numerous special units, such as a point-duty floodlight, and projectors suitable for road-repair work, as well as a representative range of lamps (both Mazda and Ediswan), fuse boxes, time switches, etc.

THE ELECTRIC STREET-LIGHTING APPARATUS CO. will show a good range of their familiar " Bi-Multi " and " Croydon " types of unit and a new adjustable directional fitting for junctions and cross-roads, a feature of which is that the reflectors can be separately adjusted to any angle; this is supplied with reflectors of either the " Bi-Multi " or " Croydon " type. For open spaces, or where directional lighting is not required, a new and effective symmetrical distribution fitting has been designed; this is likely to prove very popular in cases where a circular distribution is required. Other exhibits

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The display of THE WARDLE ENGINEERING CO. LTD. will include lanterns with both plain and directive glassware, brackets for pillar and pole mounting, water-tight boxes incorporating control gear of various types, open-type reflectors of the single and multiple lamp patterns; and also a selection of accessories for counter display. The well-known " Bruce " lantern, which attracted much attention at the British Industries Fair, will be a prominent feature of the exhibit. Another item of special interest to public lighting engineers is the new prismatic directional bulkhead fitting, which has been designed to direct the light in any desired direction, and should prove very useful for the lighting of tunnels, subways, etc.

A considerable variety of units for public lighting will be included in the display of THE ENGINEERING AND LIGHTING EQUIPMENT CO. LTD.. Amongst these may be mentioned the " Glasgow " fitting, with two-way directional band type refractor, which is suitable for lamps up to 1,500-watt capacity, and the " Trent " unit, which is somewhat similar in design but is intended for lamps up to 500 watts. New designs of the " Greenock " White Way fittings will be shown for the first time. One of these is in the form of an ornamental double bracket suitable for mounting on cast-iron columns, 12 ft. to 14 ft. high, and is suitable for 200-watt lamps; another, of the ornamental pole clamp-bracket type, is an entirely new design. It is interesting to observe that these forms of fittings have been adopted particularly widely by cities in South Africa. Other types of units to be exhibited include ornamental bracket fittings for side-street lighting, interior fittings of the " Lunax " type for public buildings, " Empire " enclosed units and time switches, etc.

Turning next to gas lighting, we learn that MESSRS. WM. SUGG & CO. LTD. will have on view a full range of their standard " Rochester," " Littleton," " Promenade," " Grosvenor," and other types of lamps, whilst the " Windsor " lamps will include several equipped with the new Holophane Directional Refracting Plates. Other items include lamps for garage lighting, back lamps for underground conveniences, and an assortment of conversion fittings for existing lamps, governors, controllers, etc.

LIGHTING TRADES LTD. and THE WELSBACH LIGHT CO. LTD. are arranging a joint exhibit of their products (Stand No. 6). A central pyramid of " Welsbach " and " Ironclad " incandescent mantles, ranging in size from ½ in. to 9 ins. high and in candle-power from 5 to 7,500, is being prepared to illustrate how completely these companies cater for the mantle requirements of the gas industry. Another feature of the exhibit will be the demonstrations of the lighting efficiency of " Renown " magnesia superheater burners, which are now being used in increasing quantities for public lighting work. " Renown " burners are now being made for clusters of 2 to 12 mantles, either Bijou or No. 2 size, with the nozzles (which are detachable) arranged in various formations according to the size of the preheating chamber. It will be recalled that the advantage of the " Renown " superheater lies in the unique construction of the interior, which is claimed to eliminate back-firing, even with greatly reduced pressure, and to ensure smooth and silent lighting and extinguishing. " Renown " burners will be shown on a number of street lanterns fitted with automatic controllers regulated to demonstrate continuous lighting and extinguishing.

MESSRS. W. PARKINSON & CO. are exhibiting a comprehensive range of street lamps and public-lighting requisites. There is on view the " Blackpool " pattern lamp, with burners arranged in tiers. This lamp is of the square type, but the patent burner is also supplied in circular lanterns and suspension and " U " fixing lamps. This arrangement of the burners results in a very important increased illuminating effect from any given number of mantles. They are also showing all types of street lamps fitted with burners having mantles in alignment (not in clusters). This arrangement obviates the loss caused by the mantles screening one another, and the maximum illumination is therefore directed along the street. A selection of burners for street-lighting purposes will be on view. These are now usually supplied metallized, thus avoiding the corrosion caused by the constant contact of the products of combustion. The arrangement of the mantles in alignment is also carried out with conversion-type burners, and some of these can be readily adapted for midnight reduction.

Messrs. Parkinson are also exhibiting a novel form of danger sign. This is equally effective during day and night, and during lighting hours the sign is illuminated by means of a suspension arc lamp attached to a swan-neck fitting. The sign is of very neat appearance, and can easily be fitted in position.

Automatic control of public lamps will be represented in the exhibits of THE HORSTMANN GEAR CO. LTD., MESSRS. VENNER TIME SWITCHES LTD., THE GAS METER CO. LTD., and RADIOVISOR PARENT LTD. We have not, up to the time of going to press, been furnished with an account of the display of the Horstmann Gear Co., but we gather it will be quite as comprehensive and interesting as in former years. Messrs. Venner Time Switches Ltd. will be showing a full range of time switches for street-lighting control, both of the hand and electrically controlled types, switches for individual posts, small groups and heavy-capacity switches for controlling large groups, etc. There will also be numerous special models, such as those designed for the G.P.O. relays of varying capacity, a time switch for a synchronous motor, and a complete range of boxes for housing street-lighting switches of all kinds.

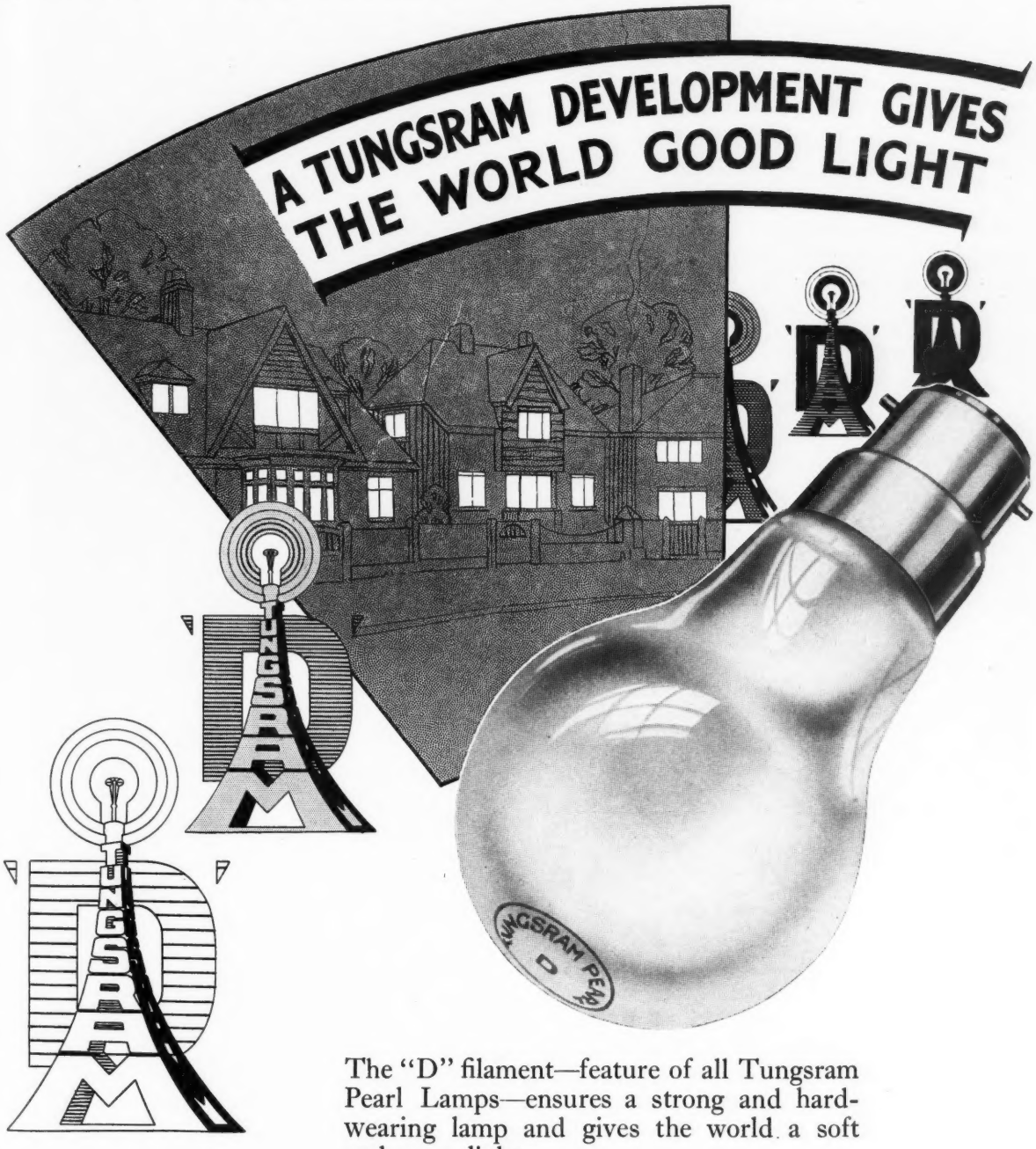
THE GAS METER CO. LTD. will show samples of their well-known " London " automatic controller, and also a controller specially adapted for shop lighting. This can be arranged to light and extinguish burners six out of the seven days of the week. There will also be a cluster-controller which, at lighting-time, puts on a complete cluster in a street lamp, but extinguishes one section at a predetermined time and the remainder at sunrise.

Lastly, we must mention a highly interesting development—the control of street lamps by means of photo-electric cells. This idea will be exemplified in the exhibit of THE GENERAL ELECTRIC CO. LTD., and also in that of RADIOVISOR PARENT LTD., whose system, we believe, has already been applied in some London suburbs. The use of a photo-electric cell would mean that lamps are automatically lighted up when darkness comes and extinguished at dawn, and would also ensure that they would operate in the event of daylight being temporarily diminished by a fog.

Proceedings, International Congress on Illumination, 1928

We recently recorded the publication of the Proceedings of the International Congress on Illumination, held in the United States about a year ago. This imposing volume, which contains upwards of 1,400 pages, is now to hand. We propose to review its contents more fully in our next issue, and we shall therefore not attempt at the moment to do more than comment on the extraordinary scope of the information presented. Application for copies of the volume, which is issued at $10, should be made to the Illuminating Engineering Society, 29, West 39th Street, New York, U.S.A.

Even this bulky volume, however, does not exhaust the data assembled last September. There remains the record of the Proceedings of the International Commission on Illumination, the session of which was likewise held in the United States. Like the preceding volume, the record of these proceedings issues from the press of the Chemical Publishing Co., and it bears on its cover the imprint of the National Physical Laboratory. It occupies over 1,200 pages and is priced at $5.



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Modern Office Lighting

An article in the *Kandem Quarterly Journal*, issued by Messrs. Korting & Mathiesen Electrical Ltd., emphasizes the importance of adequate illumination, absence of glare, and good diffusion in office lighting. Whilst semi-indirect lighting is widely adopted in offices, and totally indirect lighting is sometimes found, the use of diffusing direct-lighting units is most usual. A good example of an office so lighted is seen in Fig. 1, whilst Fig. 2 shows a familiar type of "Kandem"

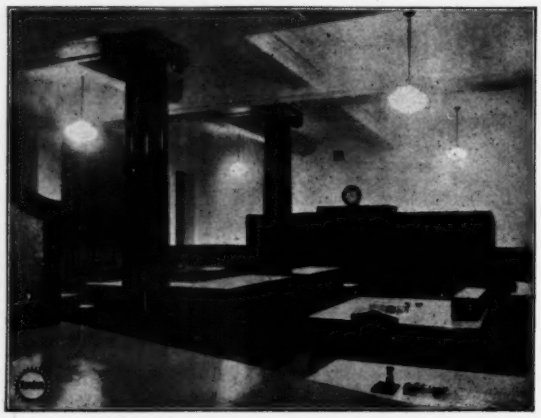

FIG. 1.—A good example of Direct Office Lighting (offices of the West Riding Trade Protection Society).

direct-lighting unit. This utilizes an opalescent one-piece globe with an exceptionally fine satin-finish surface. Such units emit the majority of the light downwards and sideways, whilst a smaller portion is directed upwards, resulting in ample illumination of the ceiling and upper parts of the room. The lighting of the office itself, where work is done, is naturally the most important problem. But adjacent corridors should not be overlooked, as it makes a bad impression to approach an office through a gloomy and ill-lighted corridor. Generally speaking, it is preferable to have a clear view down the corridor, and ceiling units of the type illustrated in Fig. 2 are widely used.

Whilst most operations in offices can be done quite satisfactorily by good general lighting, there are occasions when local units are preferred. In the article quoted some well-designed examples of these are shown. It is, of course, essential that the filament should be completely screened from the eyes of the worker. The distribution of light also requires study in order that an even and sufficient illumination may be available over a fairly wide area. A feature of these units is that they are highly adjustable, so that they can be inclined at the angle giving the best effect.

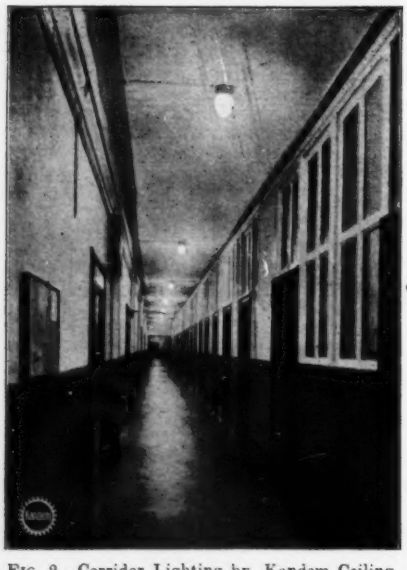

FIG. 2.—Corridor Lighting by Kandem Ceiling Units.

FIG. 3.—A typical Kandem Diffusing Unit with one-piece globe.

The Lighting of the Underground Piccadilly Circus Station

Readers will recall that an account of this interesting installation was given by Mr. S. G. Elliot at a meeting of the Illuminating Engineering Society early this year. The excellent photographs which appear below have since been received from the General Electric Co. Ltd., who furnished the means of lighting the escalators and and underground show-window lighting here illustrated.

FIG. 1.—Triple Escalator Lighting at Piccadilly Station, London, by G.E.C. Escalator Lighting Units and Osram lamps.

The opening of this new station excited much public interest. The lighting of the circular booking hall by means of Pearl lamps in diffusing-glass cylinders is on original lines, but it is the indirect lighting of the escalators, for which seventy G.E.C. lighting units were provided, that is the chief feature of this underground station. At the time of Mr. Elliot's description, we believe, the series of illuminated shop windows which encircle the large booking area was not complete. They now produce quite an imposing effect, and utilize upwards of 400 Gecoray shop-window lighting units. It seems likely that this form of advertisement, which certainly brightens the railway station considerably, will become more general in the future.

It is of interest to mention that the whole of this installation was carried out by the Signal Engineers' Department of the London Electric Railways.

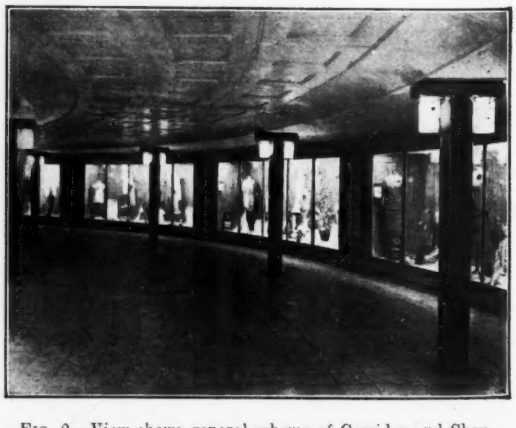

FIG. 2.—View shows general scheme of Corridor and Shop-window Lighting at Piccadilly Station, London.

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THE "VICTOR CAPSTAN"

SUITABLE
FOR LAMPS UP TO
500 Watts

Heavy weatherproof ventilated copper casing. Florentine bronze finish outside, aluminium painted inside.

Adjustable carrier for Lampolder ensures correct position of lamp.

Special 2-piece cast-iron Shackle simplifies wiring. Fitted with weatherproof cap.

No. E4403

THE "VICTOR CAPSTAN"

OVERALL
Height 24″
GLOBE 12″ Square

Globe made from our well-known **"SUPASTONE" 3-Ply GLASS** giving brilliant and uniform illumination without glare.

A special arrangement enables the globe to be held by one fixing screw only.

All four sides of the globe can be used for advertising lettering or design.

THE WHOLESALE FITTINGS CO. LTD.

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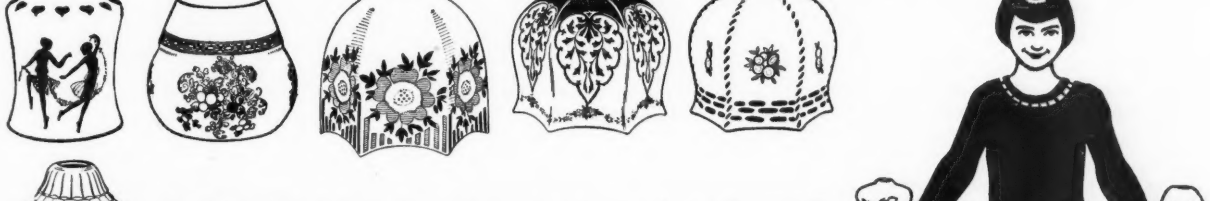
MANCHESTER: 70/80 High Street **BRISTOL: 14, North Street, Stokes Croft**



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Sole Makers:

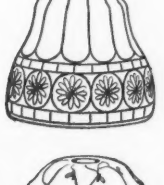
HAILWOOD & ACKROYD LTD.

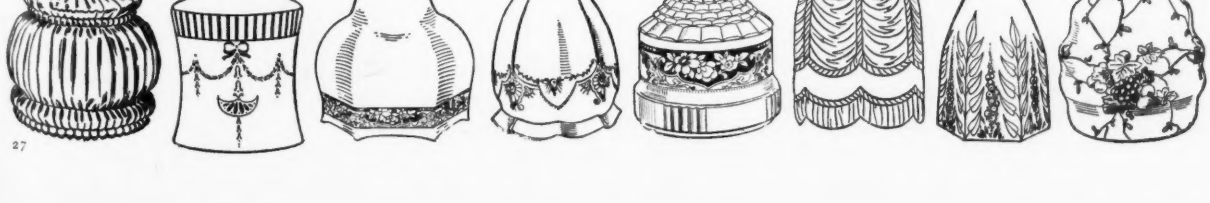
Glassmakers, Metal Stampers and Fittings Makers

Beacon Works, Morley, Leeds

Showrooms and Stockrooms:

98, Mansell Street, London, E.1.
32, Shaftesbury Avenue, London, W.1.
21, Waterloo Street, Glasgow, C.2.
28, High Street, Birmingham.



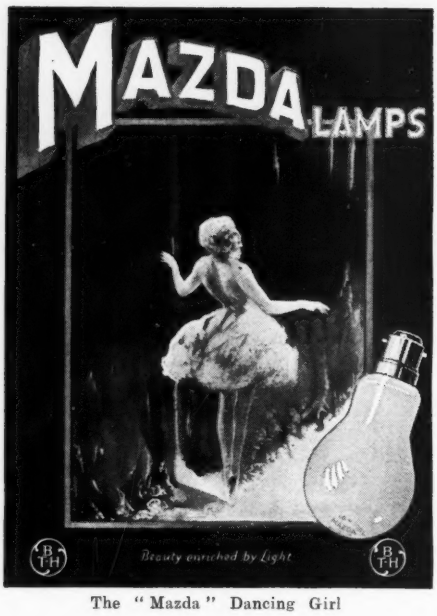


TRADE NOTES & ANNOUNCEMENTS

THE MAZDA 1929-1930 ADVERTISING CAMPAIGN.

The Mazda advertising campaign for the coming lighting season will be devoted largely to Pearl Mazda lamps. From the series of attractive posters, folders and showcards which will be available we have selected one of the most effective, the " Mazda Dancing Girl," the attractive picture by Forster, which has been a prominent feature during the past few months. Press advertising will likewise bring before the public the simplified line of the " Mazda Five " lamps. This season's catalogue contains particulars and prices of every Mazda lamp manufactured for lighting purposes and leaflets and folders dealing applications of lamps for every purpose will be furnished for overprinting with resellers' names and addresses.

Attention may also be directed to the " Mazda Five " book, a special publication to the trade only, which contains much useful information about the 1929-1930 advertising campaign. This book is cut to the outline of a figure " five."



The " Mazda " Dancing Girl

COLOURED FLOODLIGHTING.

We have also received an account of an interesting example of coloured floodlighting—the installation of 20 B.T.H. units at the medical baths at Torquay. Each of these units, which contains a 1,000 w. Mazda gasfilled lamp, is mounted on the roof of the baths and equipped with a colour screen. Groups of projectors are directed on the adjacent cliffs and beach, and one group is kept in reserve to illuminate the sea in rough weather.

The effect is said to be very striking. We understand that this is only one of a number of similar schemes with which the British Thomson-Houston Co. Ltd. have recently carried out.

CRYSELCO LTD.: NEW BRANCHES IN GLASGOW AND LIVERPOOL.

The growth of business of Messrs. Cryselco Ltd. is illustrated by the fact that two new branches have recently been opened. Mr. W. J. Stanley will be in charge of the new branch at 172, Bath Street, Glasgow, and Mr. K. R. Mackley will deal with that at 22, Sir Thomas Street, Liverpool. These developments are the more interesting because Messrs. Cryselco Ltd. are lamp manufacturers only and, as they have been in existence since 1895, can claim to be one of the oldest in Great Britain.

HOLOPHANE DEVELOPMENTS.

As will be gathered from the account recently given in this journal of the Holophane Annual Sales Conference, the company is introducing a number of attractive novelties for the coming season. On that occasion we referred to the ingenious refracting plates, which are likely to have many special applications, e.g., for lighting operating tables in hospital theatres and in photographic work. There have been considerable developments in street-lighting units, which will be fully illustrated at the exhibition arranged in connection with the Conference of the Association of Public Lighting Engineers, to be held in Bournemouth next month. At this exhibition the new " Spot-O-Lite " projector, applicable to signs, clock-faces, etc., as well as for displaying special objects in shop windows, will be on view.

Considerable progress has been made in the design of industrial lighting units, and the newly evolved " Crystolite " units, which are of very pleasing design, should prove very popular for shop lighting. Perhaps one of the most interesting novelties is the " Focalite " unit, illustrated in the adjacent illustration. This, though a totally enclosed unit, is of the concentrating type, and it is based on a new principle in reflector design. The reflector is formed with a top hemispherical contour with exterior stilletto prisms and a lower section, controlling the greater part of the light flux, with internal horizontal totally reflecting prisms giving a smooth exterior surface. The bottom member is arranged with interior refracting prisms and exterior radial flutings, forming a completely enclosed bowl. The distribution of light from these units enables them to be spaced at a distance apart equal to their height—a most unusual feature in an enclosed unit—and, as the unit combines exceptional efficiency with decorative appearance, it ought to prove a very popular one.

The new Holophane Focalite Unit.

CONTRACTS CLOSED.

The following contract is announced :—

GENERAL ELECTRIC CO. LTD :—

Hull Corporation Electricity Department; 12 months' requirements of Osram gasfilled and vacuum, also Robertson carbon-filament lamps.

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Glare and Visibility in Artificially Lighted Streets

An Experimental Investigation carried out at Sheffield in July, 1928

By W. S. Stiles, B.Sc. (The National Physical Laboratory)

[The tests described were carried out in Sheffield in July, 1928, on a number of street-lighting installations specially erected for the Conference of the Association of Public Lighting Engineers. Measurements of eye sensitivity (as measured by the least difference of brightness detectable) were made, using a special set of contrast discs. The eye sensitivity depends on the direction in which the observer looks, and varies with the number of lamps in the field of view, their candle-powers, mounting height and distance away. The most important direction of view in practice is that for an observer in the middle of the roadway with his gaze directed horizontally along the length of the street. The eye sensitivity measurements were made for this direction of view, and the results obtained correlated well with those computed using formulæ established by laboratory investigations.

Methods of appraisal depending on personal opinion were also employed. The following general results were obtained :—

(i) The observer chooses, as the position of maximum glare in the span, a position where the depression of eye sensitivity due to the first lamp (as computed from the laboratory formula) is a maximum.

(ii) The observer's estimates of the intensity of glare correlate with the depression of eye sensitivity due to the first lamp (rather than with the total depression of eye sensitivity due to all the lamps). The evidence as a whole suggests that in estimating glare the observer depends for his judgment on the general sensation of discomfort produced by the most glaring source in the field, but that the depression of eye sensitivity and the discomfort effect due to a given lamp rise and fall together.

(iii) For the ten installations tested, the estimated visibility and the estimated intensity of glare tend to increase together. The bearing on the B.E.S.A. Street Lighting Specification of the results obtained is discussed. In particular, the Glare Clause of the Specification is found to require revision.]

(*Concluded from August, 1929, page 199.*)

Analysis of the Results of Test B.—It will be convenient to deal first with Test B, as the results are needed in the discussion of Test A. It was intended originally to take as the observation positions for Test B the points where glare was most intense, as determined by the method of the Glare Appendix of the B.E.S.A. Specification, using the curves there given. When vertical illumination measurements were available, however, it was found that the m curves obtained fell entirely within the lowest constant glare loci of the appropriate B.E.S.A. diagrams. The B.E.S.A. diagrams were derived from the researches of Bordoni on the brightness difference threshold in the presence of glaring sources, and since then comprehensive investigations by Holladay and later by the writer have led to formulæ which provide a more convenient basis for glare calculations. These formulæ take the following form : for a subject viewing a field of uniform brightness B candles/square foot containing in addition light sources the angular separations of which from the fixation point equal θ_1, θ_2 . . . . θ_s degrees, the brightness difference threshold is the same as that which would be obtained for a field of uniform brightness β candles/square foot containing no other light sources, where

$$\beta = B + k \sum_{i=1}^{s} \frac{E_i}{\theta_i^n} \qquad \begin{cases} k=9\cdot2 \\ n=2\cdot0 \end{cases} \text{ Holladay} \qquad \begin{cases} k=4\cdot16 \\ n=1\cdot5 \end{cases} \text{ Stiles}$$

and where E_1 E_2 . . . . E_s are the illuminations in foot-candles in the plane of the subject's pupils due to the respective light sources. As the threshold δB, corresponding to any given field brightness in the absence of glare, is known, the threshold appropriate to any distribution of glare sources can be determined.*

The application to the present problem is immediate. For an observer standing at some point in the test span on the middle line of the road, and looking in a direction parallel to the middle line, each street lamp in the field of view contributes an amount $k \frac{E_i}{\theta_i^n}$ to β which determines the threshold, where E_i is the illumination of the observer's pupils due to the street lamp and θ_i is the angle between the observer's line of vision and the line joining the lamp to the observer's eyes. The expression $k \frac{E_i}{\theta_i^n}$ may be regarded as measuring the glaring effect of the light source in reducing the eye sensitivity of the observer. In Figs. 8, 9 and 10, the term $k \frac{E_1}{\theta_1^n}$ arising from the nearest lamp is plotted against y (which defines the position of the observer in the span) for each of the test installations except Nos. 38 and 42, and for $n=2$ and $n=\frac{3}{2}$. For installations 38 and 42 values of E_1 throughout the span were not obtained and $k \frac{E_1}{\theta_1^n}$ has been plotted instead. It is possible now to select, in each installation for which $k \frac{E_1}{\theta_1^n}$ curves are available, the position in the span at which (a) $9\cdot2 \frac{E_1}{\theta_1^2}$ (b) $4\cdot16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$ is greatest. In general, the two positions so obtained will be different. The observation positions actually used in Test B (see column 2, Table II) were selected with general reference to the positions of the maxima in the $9\cdot2 \frac{E_1}{\theta_1^2}$ curves, although in several cases other considerations influenced the choice made. No argument in the present paper is based on the assumption that the observation positions, and the maxima in the $9\cdot2 \frac{E_1}{\theta_1^2}$ curves are coincident, which in fact is not the case. For installation 33, Test B was carried out at two different observation positions.

* See Stiles', "Commission Internationale de l'Éclairage, September, 1928," where further references are given.

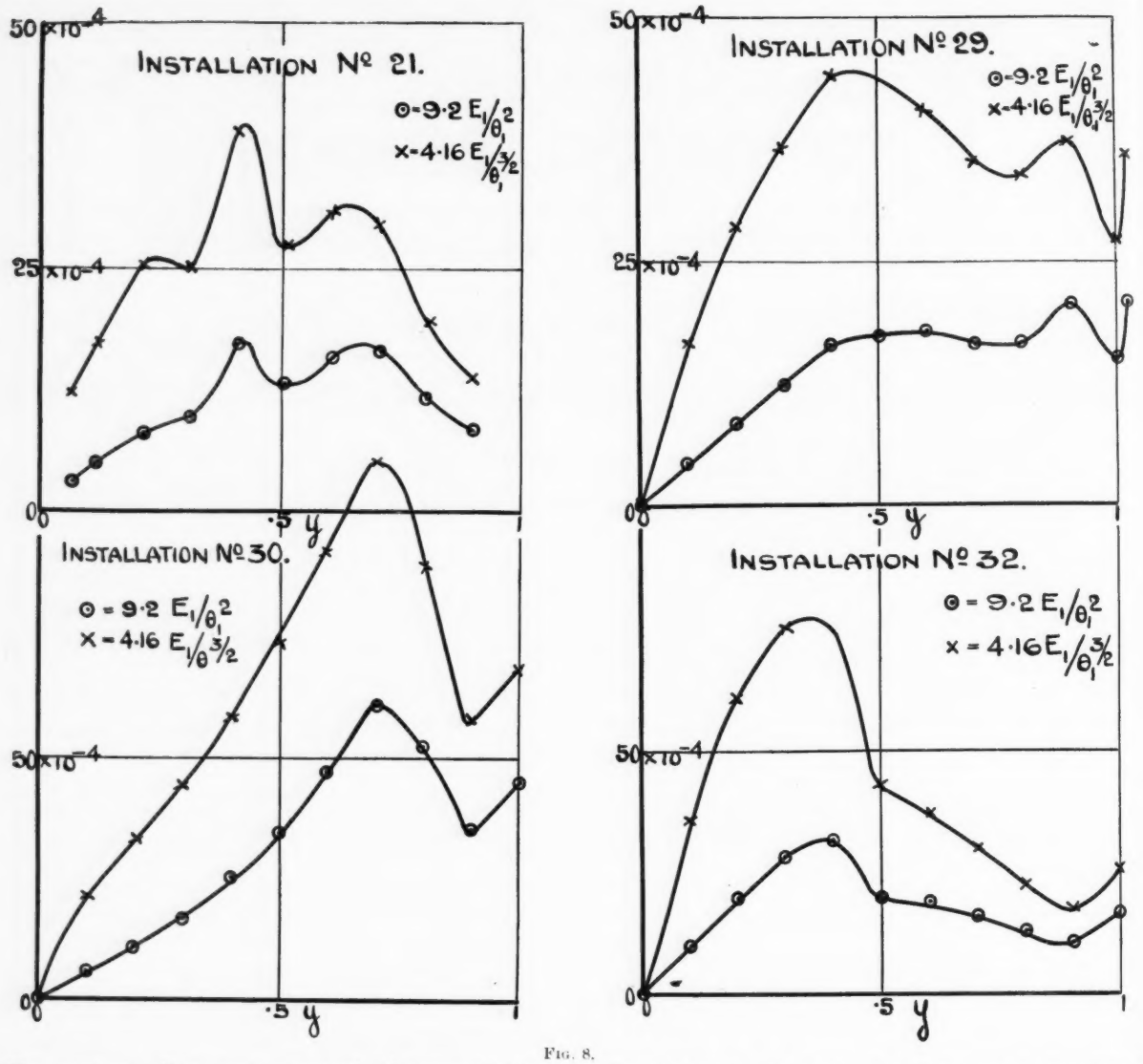

FIG. 8.

The contrast discs were prepared photographically. A sheet of gaslight paper was first exposed to light for a brief interval of time. A metal plate cut in the shape of the test spot was then laid on the paper and the light switched on again for several minutes. On development and mounting the final product was as seen in the photograph of Fig. 3. All the discs made had a dark background of reflection factor about 4 per cent. which was the lowest value obtainable, and a contrast spot of reflection factor exceeding that of the background by various amounts. If ρ_o and ρ_s are the reflection factors of background and test spot respectively, $\rho_s - \rho_o$ is the reflection factor difference giving rise to the observed contrast. With an illumination E_D foot-candles incident on the disc the difference of brightness between spot and surround is given by $E_D \frac{\rho_s - \rho_o}{\pi}$. A set of ten discs was prepared for each Test B observation position, the reflection factor differences varying by approximately equilogarithmic steps from about 0·2 to about 15 per cent.

The reflection factors were measured in the laboratory. The values obtained depend to some extent on the method of illumination used and in particular, if the angle relations are such that specular reflection occurs, the reflection factor is much higher than in the reverse case. Specular reflection was avoided in the laboratory measurements. All the discs were measured under identical conditions of illumination, but some subsidiary determinations with different conditions of illumination indicated that although the absolute reflection factor varied with the illumination conditions the reflection factor difference $\rho_s - \rho_o$ was much more nearly independent of these, specular reflection being of course avoided.

For the tests in the street, the discs were mounted on a stand with the normal to the disc inclined downwards at an angle of 30 degrees. By this means it was considered that specular reflection from the discs was practically eliminated and that the laboratory values of the reflection factor difference $\rho_s - \rho_o$ might safely be used. Surrounding the disc was a dial ring painted black, but with white dashes indicating the compass points N, SE, NW, etc.

At each installation the ten discs were presented to the observers in a known random order (i.e., not in order of increasing or decreasing reflection factor difference), each disc being placed in the stand with the contrast spot situated at a particular point of the compass unknown to the observers. From the result cards were determined for each installation, (1) the total number m of observers who carried out Test B, (2) the numbers m_c m_i and m_n of correct, incorrect and nil judgments of the test spot position for each disc. Clearly $m = m_c + m_i + m_n$. For a given disc the probability of a correct answer, deduced from the results will be given by $\xi = \frac{1}{m}\left\{m_c + \frac{1}{8}m_n\right\}$. The second term here allows for the fact that as there are only eight possible positions of the test spot a pure guess would have an eighth chance of being correct. By plotting ξ against the logarithm of the corresponding disc reflection factor difference $\overline{\rho_s - \rho_o}$, the value of $\log_{10}\overline{\rho_s - \rho_o}$ can be selected at which $\xi = 0{\cdot}5$, i.e., at which there is a 50 per cent. chance of assigning correctly the position of the spot. In practice it was found preferable to plot $\tanh^{-1} 2\ (\xi - 0{\cdot}5)$ against $\log_{10}(\rho_s - \rho_o)$ and find the value of $\log_{10}(\rho_s - \rho_o)$ at which the curve (which is sensibly linear in this region) cuts the $\log_{10}\overline{\rho_s - \rho_o}$ axis.

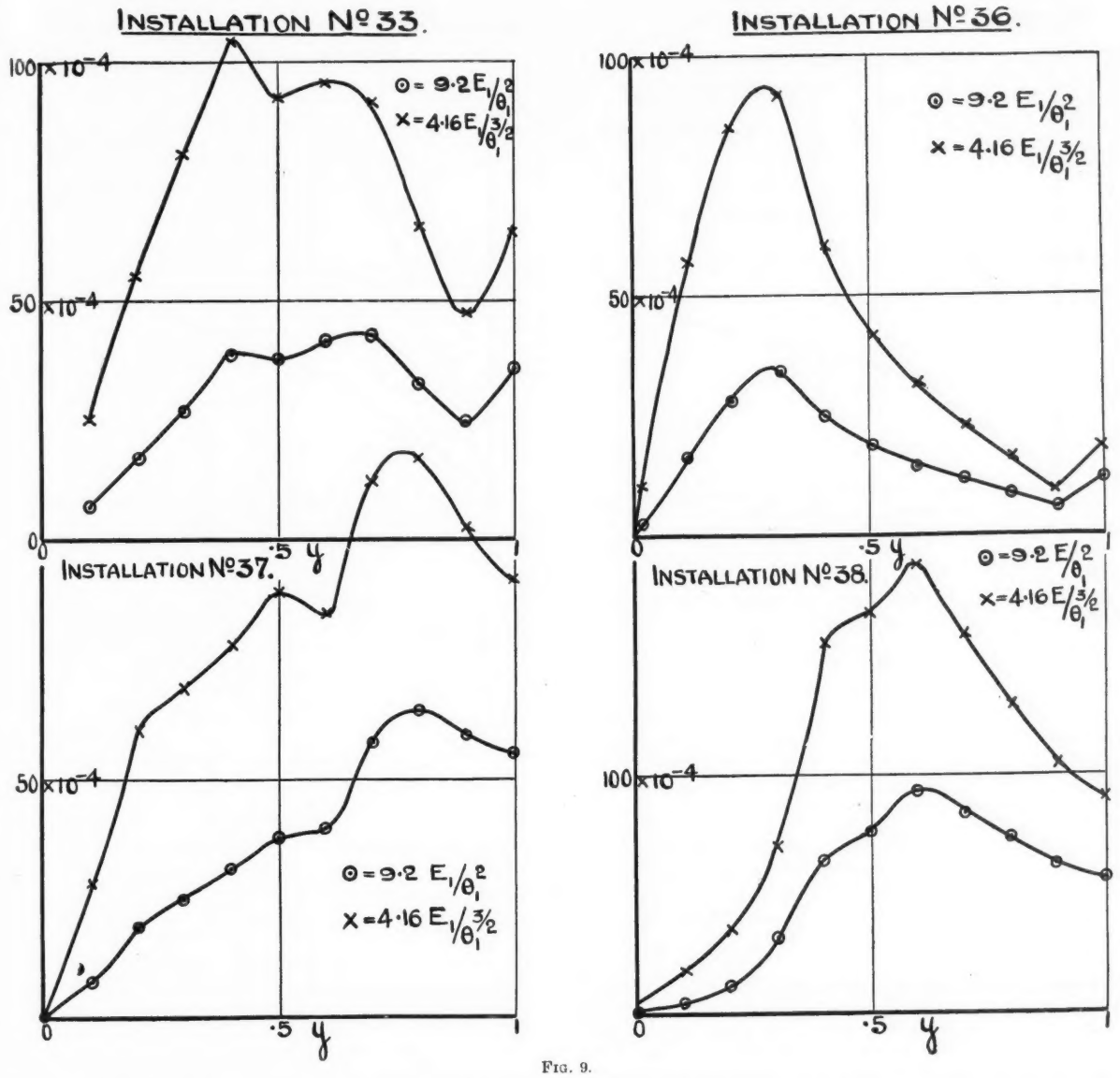

FIG. 9.

The threshold brightness difference is then given by $\frac{E_D}{\pi}(\rho_s - \rho_o)\xi = 0{\cdot}5$.* Another magnitude derivable from the results is the brightness difference necessary to give a 90 per cent. chance of a correct answer ($\xi = 0{\cdot}9$). This expressed as a multiple of the threshold brightness difference gives a comparative measure of the precision with which the latter quantity is determined by the experimental data. The complete results for the brightness difference threshold, etc., at the different Test B observation positions are summarized in Table II.

TABLE II.—RESULTS FOR TEST B.

Installation No.	Observation Position	$(\rho_s - \rho_o)\xi = 0{\cdot}5$	δB candles/sq. ft.	$\frac{(\rho_s - \rho_o)\xi = 0{\cdot}9}{(\rho_s - \rho_o)\xi = 0{\cdot}5}$
41	$y = 0{\cdot}41$	4·17%	$1{\cdot}05\ 10^{-3}$	2·0
39	0·56	3·80	2·20	3·2
40	0·73	3·09	1·02	1·7
42	0·39	2·29	1·66	2·6
43	0·44	2·29	1·73	2·3
36	0·72	6·61	3·62	3·0
37	0·39	3·39	2·00	2·1
38	0·77	7·41	1·77	3·5
42	0·60	6·61	2·23	2·6
44	1·00	4·36	2·00	3·3
	0·66	3·31	2·83	2·0
			Mean	2·6

The computation of the threshold value to be expected from the results of laboratory measurements of thresholds will now be considered. We have to determine the effective background brightness corresponding to each observation position, using the formula $\beta = B + k\sum_{i=1}^{s}\frac{E_i}{\theta_i^n}$.

The background brightness B on which the threshold brightness difference is produced must be taken as the brightness of the background of the contrast discs. This will be given by $\frac{E_D\,\rho_o}{\pi}$. In the laboratory experiments the background brightness covers a large area of the visual field, whereas here the angle subtended at the eye by the average apparent diameter of the dial ring † amounts to not more than 1·1 degrees. Field brightnesses lying outside the dial ring and which materially exceed the background brightness must therefore be included in the glare term of the β formula.‡ The contribution to the glare term of the nearest lamp, $k\frac{E_1}{\theta_1^n}$

* Strictly speaking the threshold should be derived from the value of $\rho_s - \rho_o$ at which ξ has a value rather greater than 0·5, to allow for the chance of a pure guess being correct. The original calculations were made with $\xi = 0{\cdot}5$, and as the necessary correction does not affect significantly the final results, it has not been thought worth while to repeat the work.

† The dial ring is included with the contrast disc as forming the background. The reflection factors of the dial ring and the contrast disc background are effectively the same for the present purpose.

‡ The use of the β formula in this way has not been established directly by experiment. There is, however, evidence available that in the present case the field brightnesses outside the dial ring are responsible for only a small percentage of the threshold, and the method used is therefore an adequate approximation.

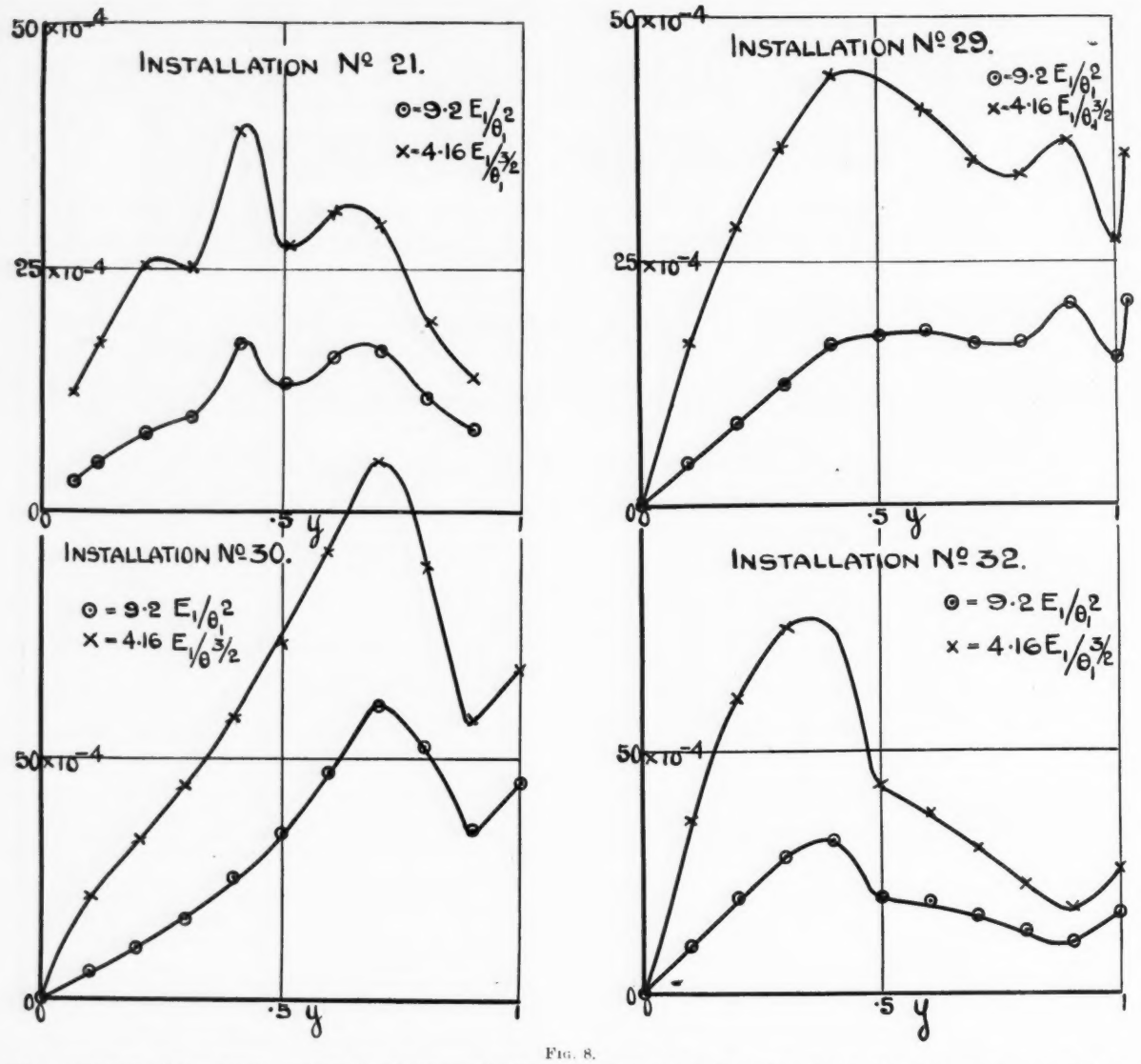

FIG. 8.

The contrast discs were prepared photographically. A sheet of gaslight paper was first exposed to light for a brief interval of time. A metal plate cut in the shape of the test spot was then laid on the paper and the light switched on again for several minutes. On development and mounting the final product was as seen in the photograph of Fig. 3. All the discs made had a dark background of reflection factor about 4 per cent. which was the lowest value obtainable, and a contrast spot of reflection factor exceeding that of the background by various amounts. If ρ_o and ρ_s are the reflection factors of background and test spot respectively, $\rho_s - \rho_o$ is the reflection factor difference giving rise to the observed contrast. With an illumination E_D foot-candles incident on the disc the difference of brightness between spot and surround is given by $E_D \frac{\rho_s - \rho_o}{\pi}$. A set of ten discs was prepared for each Test B observation position, the reflection factor differences varying by approximately equilogarithmic steps from about 0·2 to about 15 per cent.

The reflection factors were measured in the laboratory. The values obtained depend to some extent on the method of illumination used and in particular, if the angle relations are such that specular reflection occurs, the reflection factor is much higher than in the reverse case. Specular reflection was avoided in the laboratory measurements. All the discs were measured under identical conditions of illumination, but some subsidiary determinations with different conditions of illumination indicated that although the absolute reflection factor varied with the illumination conditions the reflection factor difference $\rho_s - \rho_o$ was much more nearly independent of these, specular reflection being of course avoided.

For the tests in the street, the discs were mounted on a stand with the normal to the disc inclined downwards at an angle of 30 degrees. By this means it was considered that specular reflection from the discs was practically eliminated and that the laboratory values of the reflection factor difference $\rho_s - \rho_o$ might safely be used. Surrounding the disc was a dial ring painted black, but with white dashes indicating the compass points N, SE, NW, etc.

At each installation the ten discs were presented to the observers in a known random order (i.e., not in order of increasing or decreasing reflection factor difference), each disc being placed in the stand with the contrast spot situated at a particular point of the compass unknown to the observers. From the result cards were determined for each installation, (1) the total number m of observers who carried out Test B, (2) the numbers m_c m_i and m_n of correct, incorrect and nil judgments of the test spot position for each disc. Clearly $m = m_c + m_i + m_n$. For a given disc the probability of a correct answer, deduced from the results will be given by $\xi = \frac{1}{m}\left\{m_c + \frac{1}{8}m_n\right\}$. The second term here allows for the fact that as there are only eight possible positions of the test spot a pure guess would have an eighth chance of being correct. By plotting ξ against the logarithm of the corresponding disc reflection factor difference $\overline{\rho_s - \rho_o}$, the value of $\log_{10} \overline{\rho_s - \rho_o}$ can be selected at which $\xi = 0{\cdot}5$, i.e., at which there is a 50 per cent. chance of assigning correctly the position of the spot. In practice it was found preferable to plot $\tanh^{-1} 2\ (\xi - 0{\cdot}5)$ against $\log_{10} (\rho_s - \rho_o)$ and find the value of $\log_{10} (\rho_s - \rho_o)$ at which the curve (which is sensibly linear in this region) cuts the $\log_{10} \overline{\rho_s - \rho_o}$ axis.

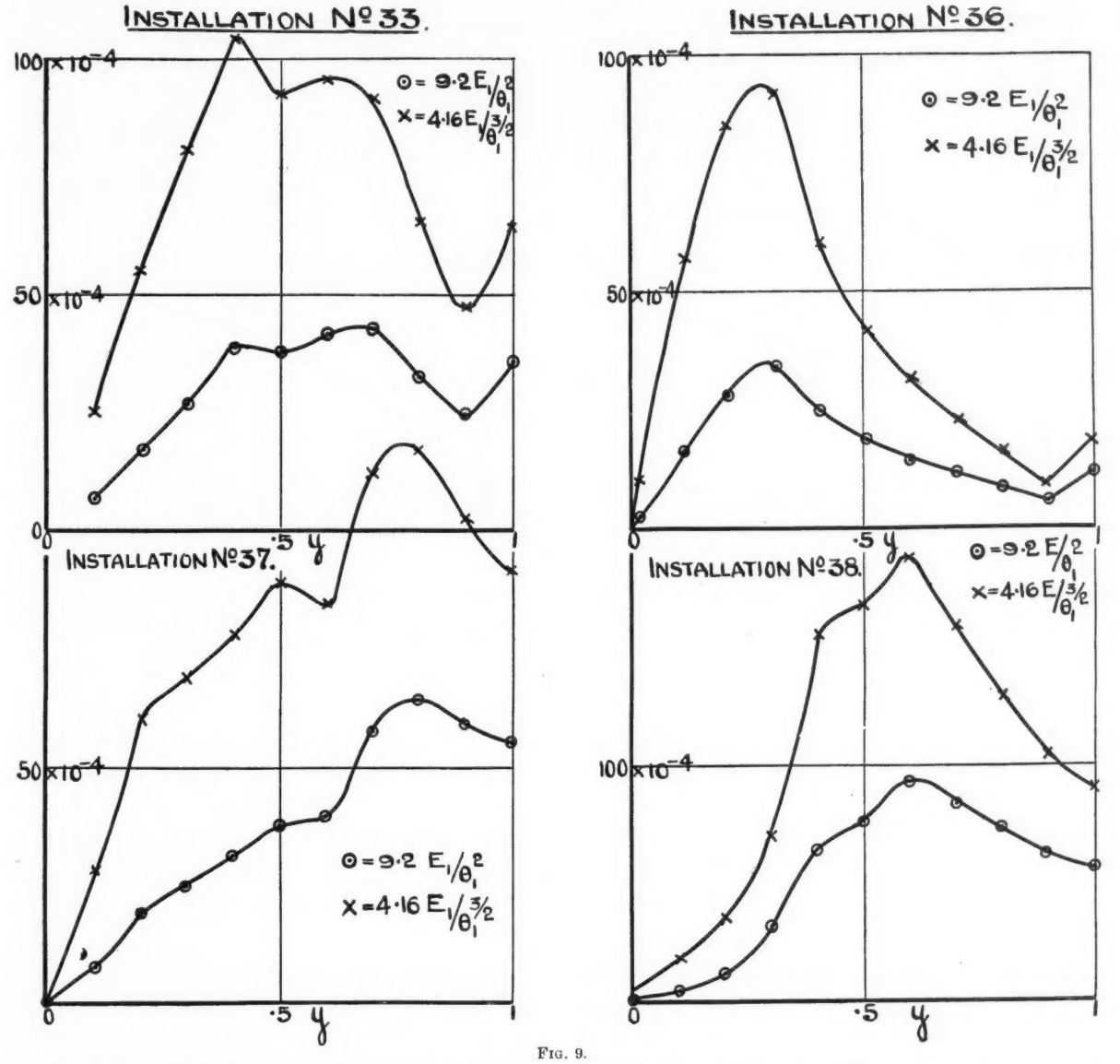

FIG. 9.

The threshold brightness difference is then given by $\frac{E_D}{\pi}(\rho_s - \rho_o)\xi = 0{\cdot}5$.* Another magnitude derivable from the results is the brightness difference necessary to give a 90 per cent. chance of a correct answer ($\xi = 0{\cdot}9$). This expressed as a multiple of the threshold brightness difference gives a comparative measure of the precision with which the latter quantity is determined by the experimental data. The complete results for the brightness difference threshold, etc., at the different Test B observation positions are summarized in Table II.

TABLE II.—RESULTS FOR TEST B.

allation No.	Observation Position	$(\rho_s - \rho_o)\xi = 0{\cdot}5$	δB candles/sq. ft.	$\frac{(\rho_s - \rho_o)\xi = 0{\cdot}9}{(\rho_s - \rho_o)\xi = 0{\cdot}5}$
21	$y = 0{\cdot}41$	4·17%	$1{\cdot}05\ 10^{-3}$	2·0
29	0·56	3·80	2·20	3·2
30	0·73	3·09	1·02	1·7
32	0·39	2·29	1·66	2·6
33	0·44	2·29	1·73	2·3
	0·72	6·61	3·62	3·0
36	0·39	3·39	2·00	2·1
37	0·77	7·41	1·77	3·5
38	0·60	6·61	2·23	2·6
42	1·00	4·36	2·00	3·3
44	0·66	3·31	2·83	2·0
			Mean	2·6

The computation of the threshold value to be expected from the results of laboratory measurements of thresholds will now be considered. We have to determine the effective background brightness corresponding to each observation position, using the formula $\beta = B + k\sum_{i=1}^{s}\frac{E_i}{\theta_i^n}$. The background brightness B on which the threshold brightness difference is produced must be taken as the brightness of the background of the contrast discs. This will be given by $\frac{E_D\,\rho_o}{\pi}$. In the laboratory experiments the background brightness covers a large area of the visual field, whereas here the angle subtended at the eye by the average apparent diameter of the dial ring † amounts to not more than 1·1 degrees. Field brightnesses lying outside the dial ring and which materially exceed the background brightness must therefore be included in the glare term of the β formula.‡ The contribution to the glare term of the nearest lamp, $k\frac{E_1}{\theta_1^n}$

* Strictly speaking the threshold should be derived from the value of $\rho_s - \rho_o$ at which ξ has a value rather greater than 0·5, to allow for the chance of a pure guess being correct. The original calculations were made with $\xi = 0{\cdot}5$, and as the necessary correction does not affect significantly the final results, it has not been thought worth while to repeat the work.

† The dial ring is included with the contrast disc as forming the background. The reflection factors of the dial ring and the contrast disc background are effectively the same for the present purpose.

‡ The use of the β formula in this way has not been established directly by experiment. There is, however, evidence available that in the present case the field brightnesses outside the dial ring are responsible for only a small percentage of the threshold, and the method used is therefore an adequate approximation.

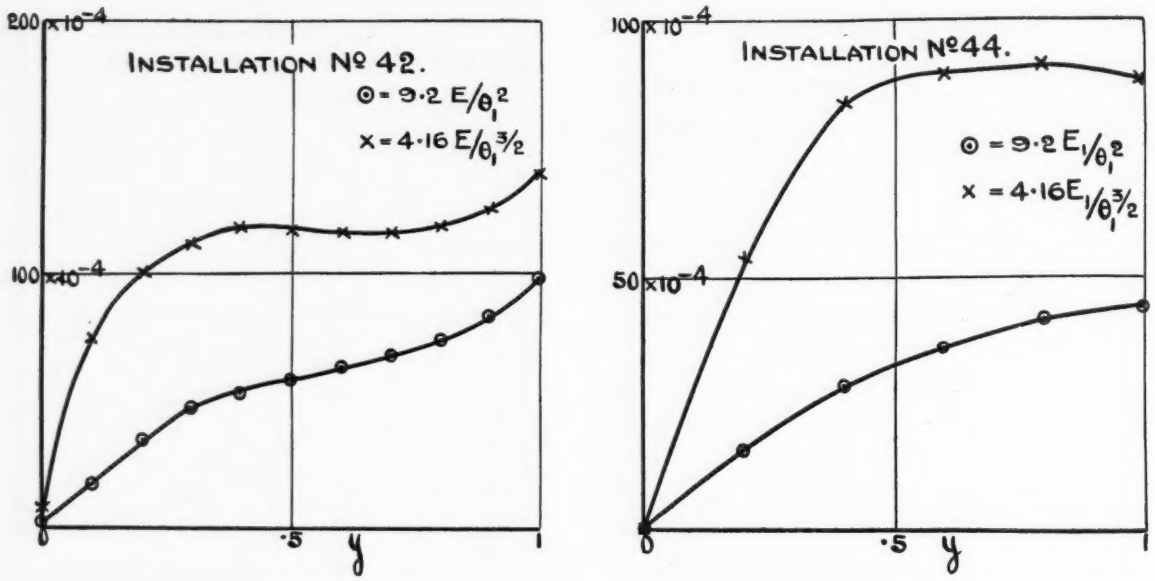

FIG. 10.

has already been computed for all positions in the span, and it is only necessary to read off from the curves of Figs. 8, 9 and 10 the values of $k \frac{E_1}{\theta_1^n}$ at the observation positions. (For installations 38 and 42 no difficulty arises, as the values of E_1 at the respective observation positions are available). The contributions of the remaining lamps and of other high brightnesses in the field are more difficult to estimate, as it was quite impracticable to measure separately the values of E_2, E_3, etc. An approximate estimate may be obtained, however, by the following device. The total pupillary illumination E is made up of the contributions of the light sources E_1, $E_2 \ldots . E_s$ and a contribution E_o due to other brightnesses in the field which materially exceed the background brightness $\frac{E_D \rho_o}{\pi}$. Thus $E = E_1 + E_2 \ldots . E_s + E_o$.

It is now assumed that the actual glare effect, omitting that due to the nearest lamp, is the same as if the contributions of all lamps except the first were each greater by a given proportional amount α, the contribution of the other brightnesses in the field being zero, where α is given by

$$(1 + \alpha)\left\{E_2 + E_3 + \ldots E_s\right\} = E_2 + E_3 + \ldots E_s + E_o = E - E_1$$

It is further assumed that as an approximation the candle power of all the lamps after the first may be treated as a constant which is so determined that when account is taken of the different distances of the lamps from the observation position the observed value of $(E - E_1)$ is obtained. If these different distances are d_2, d_3, ... d_s, the assumed common candle power C is given by

$$C\left\{\frac{1}{d_2^2} + \frac{1}{d_3^2} \cdot \ldots + \frac{1}{d_s^2}\right\} = E - E_1$$

and the total glare term becomes $k \frac{E_1}{\theta_1^n} + k\, C \sum_{i=2}^{s} \frac{1}{d_i^2\, \theta_i^n}$.

The number of lamps visible to the observer and their angular separations θ_i from the disc centre were determined from the photographs taken in the observation positions. The determination of the distance from the observation position of each lamp seen, presented no difficulty and hence all the data necessary for evaluating the glare contributions were available. Having determined β from the formula

$$\beta = \frac{E_D \rho_o}{\pi} + \frac{k E_1}{\theta_1^n} + k\, C \sum_{i=2}^{s} \frac{1}{d_i^2\, \theta_i^n}$$

δB was obtained from the empirical curves relating difference threshold and background brightness as given in the investigations underlying the β formulæ. The results of calculations carried out by this method are summarized in Table III. The observed values of δB are plotted against the values computed using the two β formulæ, in Figs. 11 and 12.

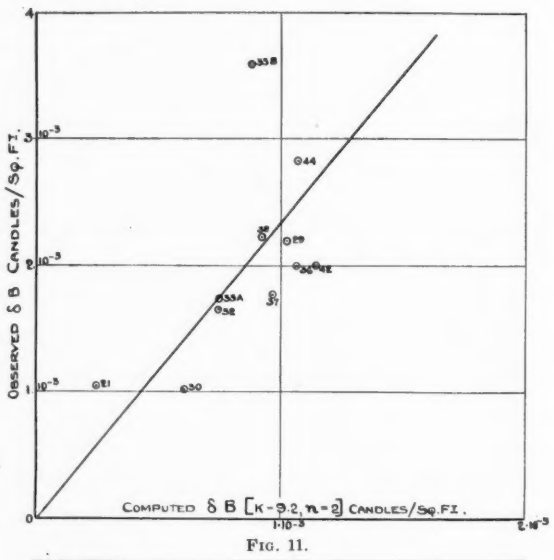

FIG. 11.

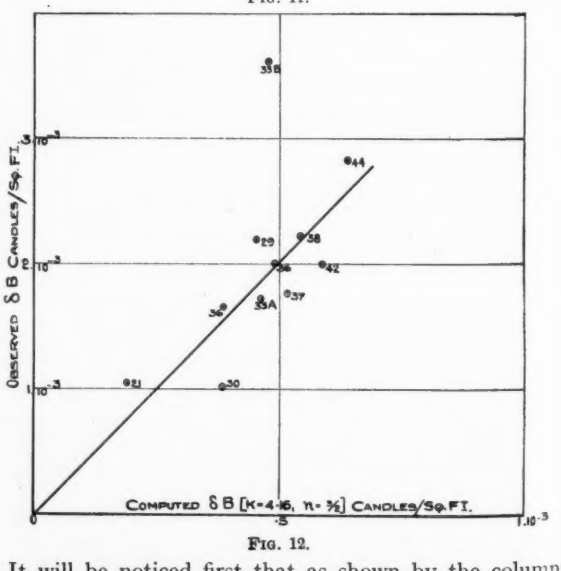

FIG. 12.

It will be noticed first that as shown by the columns 8 and 16 of Table III the observed value of δB is approximately 2·5 times the computed value with $k = 9{\cdot}2$, $n = 2$, and 4·4 times the computed value with $k = 4{\cdot}16$,

TABLE III.—COMPUTED THRESHOLDS FOR TEST B.

Installation No.	y	$\frac{E_D \rho_o}{\pi}$	$k \frac{E_1}{\theta_1^2}$	$k = 9{\cdot}2,\ n = 2$			
				$k \sum_{i=1}^{s} \frac{E_i}{\theta_i^n}$	β	δB Computed candles sq. ft.	$\delta B \frac{\text{Observed}}{\text{Computed}}$
21	0·41	$1{\cdot}01\ 10^{-3}$	$1{\cdot}74\ 10^{-3}$	$5{\cdot}34\ 10^{-3}$	$6{\cdot}35\ 10^{-3}$	$0{\cdot}239\ 10^{-3}$	4·39
29	0·56	2·33	1·81	34·3	36·6	1·020	2·16
30	0·73	1·33	5·62	17·9	19·2	0·600	1·70
32	0·39	2·92	2·93	21·9	24·8	0·740	2·24
33 A	0·44	3·03	4·28	22·1	25·1	0·746	2·32
33 B	0·72	2·00	4·32	28·5	30·5	0·880	4·12
36	0·39	2·37	2·75	36·0	38·4	1·060	1·89
37	0·77	0·96	6·35	33·1	34·1	0·964	1·84
38	0·60	1·36	8·34	31·8	33·2	0·920	2·42
42	1·00	1·84	3·56	40·4	42·2	1·150	1·74
44	0·60	3·43	3·78	34·6	38·0	1·050	2·69
						Mean	2·50

TABLE III.—COMPUTED THRESHOLDS FOR TEST B.—*continued.*

Installation No.	y	$\frac{E_D \rho_o}{\pi}$	$k \frac{E_1}{\theta_{12}^{\frac{3}{2}}}$	$k = 4{\cdot}16,\ n = 1{\cdot}5$			
				$k \sum_{i=1}^{s} \frac{E_i}{\theta_i^n}$	β	δB Computed	$\delta B \frac{\text{Observed}}{\text{Computed}}$
21	0·41	$1{\cdot}01\ 10^{-3}$	$3{\cdot}97\ 10^{-3}$	$7{\cdot}70\ 10^{-3}$	$8{\cdot}71\ 10^{-3}$	$\cdot188\ 10^{-3}$	5·58
29	0·56	2·33	4·24	27·0	29·3	·454	4·84
30	0·73	1·33	10·00	22·1	23·4	·384	2·66
32	0·39	2·92	7·10	20·6	23·5	·386	4·30
33 A	0·44	3·03	11·20	26·6	29·6	·462	3·71
33 B	0·72	2·00	9·23	28·9	30·9	·479	7·55
36	0·39	2·37	6·86	29·9	32·3	·491	4·07
37	0·77	0·96	11·80	33·2	34·2	·516	3·43
38	0·60	1·36	17·00	36·0	37·4	·542	4·12
42	1·00	1·84	5·17	38·9	40·7	·587	3·41
44	0·60	3·43	9·14	40·9	44·3	·639	4·43
						Mean	4·38

$n = \frac{3}{2}$. The discrepancy is perhaps not so serious as might at first appear when it is remembered that even laboratory investigations show differences of the same order of magnitude. For example, over a wide range of background brightnesses in the absence of glare the threshold values of the Holladay investigation are, in fact, about double those obtained in the writer's work. The conditions of observation have a very great effect on the measured values of the threshold. The smallness of the test spot in the outdoor measurements is no doubt an important factor tending to lead to a high threshold value.

Of more importance than the comparison of the absolute values is the correlation between observed and computed thresholds. It is seen from the Figs. 11 and 12 that omitting the threshold value for installation 33 observation position B, the observed and computed thresholds conform to a proportionality relation as well as could be expected bearing in mind (1) the experimental errors to which the observed δB is subject and (2) the approximate character of the assumptions made in deriving the computed δB. The anomalous point for No. 33*B* is difficult to explain except by assuming an error in the measurement of E_D. The fact that there is no other anomaly in the results for this installation or observation position leads the writer to think that this is the correct explanation. The straight lines shown in the figures are δB observ. = 2·33 δB calc. ($n = 2$) and δB observ. = 4·06 δB calc. ($n = \frac{3}{2}$) where 2·33 and 4·06 are the mean values of δB observ. /δB calc. omitting the threshold value for No. 33*B*. A measure of the departure from a proportionality relation between δB observ. and δB calc. is provided by the square root of the mean square deviation from the mean, divided by the mean, for the ratio δB observ./ δB calc. This comes out to be (omitting No. 33 *B*), for $n = 2$, 0·29; for $n = 1{\cdot}5$, 0·19. Thus a distinctly better correlation between observed and computed thresholds is obtained using the β formula with $n = \frac{3}{2}$, $k = 4{\cdot}16$.

Analysis of A Tests.—A (2). The mean of the estimated positions of maximum glare is given for each installation in column 2 of Table IV.

A comparison will now be made of the estimated positions and those which may be expected from calculations of the glare effect. A position at which the glare effect computed for the nearest lamp is a maximum is not in general a position at which the total glare effect due to all the lamps is a maximum. The sum of the contributions due to the more distant lamps is, however, a comparatively slowly varying function of position in the test span, and provided the maximum in the glare contribution of the nearest lamp is fairly sharp the

TABLE IV.

Installation	Mean estimated position of maximum glare		Mean estimated Glare Intensity at estimated maximum glare position. D.	Mean estimated General Visibility. V.
21	y =	·63	1·45	2·78
29		·46	2·23	3·41
30		·56	2·60	3·47
32		·33	2·20	3·27
33	Two positions given	A ·35	3·07	3·71
		B ·64		
	One position given	·41		
36		·27	2·52	3·17
37		·54	2·73	3·41
38		·53	3·44	2·87
42		·44	2·94	3·73
44		·50	1·70	3·73

corresponding maximum in the total glare effect will occur at the same place in the span. In view of this and because the computation of the total glare effect at all points along the span would have involved long and laborious calculations which the precision of the results obtained would not justify, the comparison made will be between the estimated maximum glare positions and the positions of maximum glare from the nearest lamp only. We shall refer to Figs. 8, 9 and 10, where $9{\cdot}2 \frac{E_1}{\theta_1^2}$ and $4{\cdot}16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$ are plotted against y for the different installations.

Installation 21.—Both computed curves show multiple peaks, their positions being for $n = 2$, $y_1 = \cdot 43$, $y_2 = \cdot 65$, and for $n = \frac{3}{2}$, $y_1 = \cdot 23$, $y_2 = \cdot 43$, $y_3 = \cdot 63$. The maximum glare position is in each case at $y = \cdot 43$. The mean estimated glare position equals 0·63, which agrees best with the peaks at $y = \cdot 65$ ($n = 2$), $y = \cdot 63$ ($n = \frac{3}{2}$). A number of observers placed the maximum glare position at the beginning of the span ($y = 1 \cdot 0$). There is no indication of a reason for this, in the computed curves.

Installation 29.—The computed curves show two peaks:

$n = 2$; $y_1 = \cdot 56$, $y_2 = \cdot 91$, Max. glare position $y_2 = \cdot 91$
$n = 1 \cdot 5$; $y_1 = \cdot 43$, $y_2 = \cdot 89$ „ „ „ $y_1 = \cdot 43$
Mean estimated position, $y = \cdot 46$

The computed glare curves kick up anomalously at the end of the span. This occurs for nearly all the installation and is probably due to an experimental error in determining E_1. At this position in the span, the man taking the illuminometer reading is nearly under the lamp, and an appreciable amount of light is reflected from his face and clothing on to the opal test surface on which the illumination is being measured.

Installations 30, 32, 36.—The computed glare curves have in each case a single peak, the position of which is the maximum glare position.

Installation	Maximum glare position $n=2$	$n=1 \cdot 5$	Mean Estimated position
30	$y = \cdot 71$	$y = \cdot 68$	$y = \cdot 56$
32	·38	·35	·33
36*	·30	·28	·27

Installation 33.—There are two peaks in each of the computed curves.

$n = 2$; $y_1 = \cdot 43$, $y_2 = \cdot 66$ Max. glare position $y_2 = \cdot 66$
$n = 1 \cdot 5$; $y_1 = \cdot 39$, $y_2 = \cdot 62$ „ „ „ $y_1 = \cdot 39$

For installation 33 the following special considerations apply. Observers had the hint that two positions of maximum glare were expected for this installation from the allowance of two spaces in the result card and from other details in the arrangements. It was found on examining the completed result cards that most observers had detected two maximum glare positions, but that others recorded one only. In deriving the mean estimated positions, three means are obtained, the means of the higher and lower estimates for those observers who gave two positions, and the mean of the single values for those who gave one only.

Estimated positions.

Two positions given, 23 observers $\begin{cases} y_1 = \cdot 35 \\ y_2 = \cdot 64 \end{cases}$
One position given, 10 observers $y = \cdot 41$

Installation 37.—For $n = 2$ there is one peak only, for $n = \frac{3}{2}$, two.

$n = 2$; $y = \cdot 78$, Max. glare position $y = \cdot 78$
$n = \frac{3}{2}$; $y_1 = \cdot 52$, $y_2 = \cdot 74$ „ „ „ $y_2 = \cdot 74$
Estimated position, $y = \cdot 54$

Installation 38.—For this installation $k \frac{E_1}{\theta_1^n}$ is not available for all points along the span, and $k \frac{E}{\theta_1^n}$ has been plotted instead. There is a fairly sharp maximum in each of the $k \frac{E}{\theta_1^n}$ curves, situated in a region where isolated measurements of E_1 show that $E - E_1$ is small compared with E (about 10 per cent.). Furthermore $E - E_1$ is varying only comparatively slowly with y, so that the positions of the maxima for the $k \frac{E_1}{\theta_1^n}$ and $k \frac{E}{\theta_1^n}$ curves must be practically identical.

We have then

$n = 2$; Maximum glare position, $y = \cdot 60$
$n = \frac{3}{2}$; „ „ „ $y = \cdot 56$
Estimated position, $y = \cdot 53$

Installation 42.—For this installation, again only the $k \frac{E}{\theta_1^n}$ curves are available. Here, however the greatest value of $k \frac{E}{\theta_1^n}$ is at the end of the span where in fact an isolated measurement shows that E_1 is only about 40 per cent. of E. In the case of $n = \frac{3}{2}$, there is one peak, situated at $y = 0 \cdot 40$. At this position conditions are probably similar to those assumed above for installation 38, and it is justifiable to take $y = 0 \cdot 40$ as the position of maximum glare. For $n = 2$, the $k \frac{E}{\theta^n}$ curve has no peak and it is not possible to arrive at the maximum glare position with the data available. The probable reason for the failure for $n = 2$ is that although there may be a peak in the $9 \cdot 2 \frac{E_1}{\theta_1^2}$ curve, it is considerably to the right of $y = 0 \cdot 40$, and in a region where $E - E_1$ and E_1 are of much the same magnitude.

Estimated position, $y = \cdot 44$.

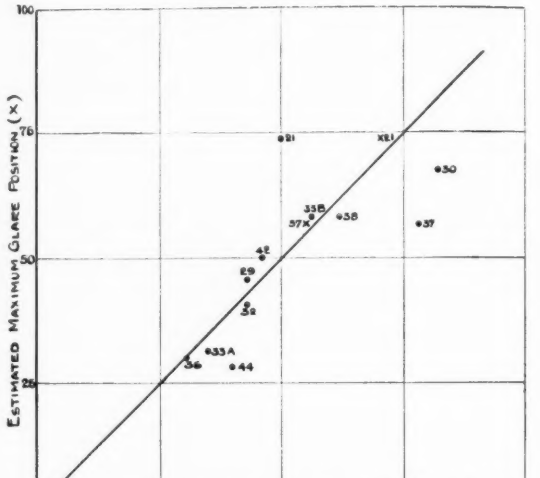

FIG. 13.

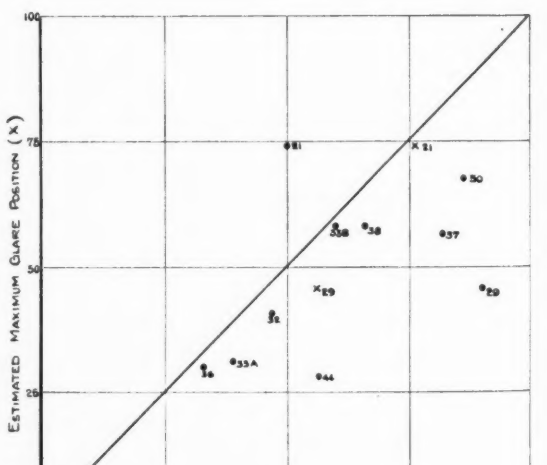

FIG. 14.

Installation 44.—The $9 \cdot 2 \frac{E_1}{\theta_1^2}$ curve has its maximum value at the end of the span. The $4 \cdot 16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$ curve exhibits a very flat peak at $y = \cdot 71$.

$n = 2$; Max. glare position $y = 1$
$n = \frac{3}{2}$; „ „ „ $y = \cdot 71$
Mean estimated position, $y = \cdot 50$

* It is of interest to note for this installation, where computed and estimated maximum glare positions agree well, that the observation position for Test B was at $y = 0 \cdot 39$, which is widely different from the maximum glare position computed or estimated. The suggestion that the white mark on the road, used to identify the Test B observation position, seriously biassed the observers' estimates of the maximum glare position appears unlikely in the light of the results for this installation.

The mean estimated positions are plotted against the computed maximum glare positions in Figs. 13 and 14, the straight line in each graph corresponding to equality of observed and calculated positions.

For $n = \frac{3}{2}$, seven of the plotted points lie very near to the "equality" line and are evenly distributed on either side of it. Of the four points which diverge appreciably, 21 and 37 are cases where more than one peak is present in the $4 \cdot 16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$ curves. If instead of the greatest the second peak is regarded as the computed maximum glare position, these installations are brought on to the "equality" line as shown by the x-points in the graph. The peak for installation 44 is so flat that agreement between observed and calculated positions is scarcely to be expected. The mean observed position corresponds actually to the sharp downward turn of the $k \frac{E_1}{\theta_1^{\frac{3}{2}}}$ curve. There seems to be no special circumstance to account for the anomaly of 30.

For $n = 2$, all but one point lie below the equality line. As in the case of $n = \frac{3}{2}$, choice of a different peak for two of the installations (21 and 29) brings the corresponding points nearer the equality line.

A comparison of the two graphs shows clearly that a definitely better correlation between observed and computed maximum glare positions is obtained using the $n = \frac{3}{2}$ formula.

Before passing on to the other A tests it may be well to emphasize the following points. The computed maximum glare positions relate to the effect on eye sensitivity, of the nearest lamp. As pointed out above, in most cases practically the same positions would have been obtained if the total effect on eye sensitivity due to all the lamps had been referred to. It is, however, unlikely that the observer selects the maximum glare position by carrying out for himself some crude form of visibility test, such as concentrating on an object ahead and finding the position where most detail can be seen. It is more probable that at the position chosen the observer feels the glare to be most annoying in a general sense. In other words the position selected is one of maximum ocular discomfort. There is no difficulty in assuming, too, that the effects of the different lamps in producing discomfort can be separated out by the observer, and that it will be the position at which the discomfort produced by the nearest lamp is a maximum that is taken as the maximum glare position. Comparison with the effect on eye sensitivity due to the nearest lamp is therefore not only more convenient but also, according to this view, more appropriate than a comparison with the total glare effect of all the lamps.

If the suggestion outlined above is substantially correct, then the observed correlation between observed and computed maximum glare positions indicates that the sense of ocular discomfort, due to a light source and its effect on eye sensitivity, rise and fall together; where one is a maximum so is the other.

A (3). The means for the different installations of the observers' estimates of the intensity of glare at the selected position of maximum glare are shown in column 3, Table IV. Following up the suggestion of the previous paragraph, it is of interest to see what correlation there is between these mean glare figures (D) and (a) the values of $4 \cdot 16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$ (measuring the glare effect of the nearest lamp at the mean estimated position of maximum glare) and (b) the values of $4 \cdot 16 \sum_{i=1}^{s} \frac{E_1}{\theta_i^{\frac{3}{2}}}$ (measuring the total glare effect of all the lamps) at this position.* The appropriate graphs are shown in Figs. 15 and 16. It is seen by inspection that the stronger correlation is between the estimated glare figures and the glare effect of the nearest lamp. The evaluation of the correlation coefficients confirms this suggestion, the coefficients in the two cases being 0·81 and 0·46 respectively. A straight line has been drawn in Fig. 15 to represent the variation of glare figure with $4 \cdot 16 \frac{E_1}{\theta_1^{\frac{3}{2}}}$. The point for No. 44 lies considerably farther from the line than do the other points. At this installation the observers reckoned the glare to be markedly less than that to be anticipated from the computed effect.

A (1). Finally the mean estimated general visibility figures (V) must be considered (column 4, Table IV).

For installations 21 and 38, the mean values of V are lowest. For these installations, however, the wattage

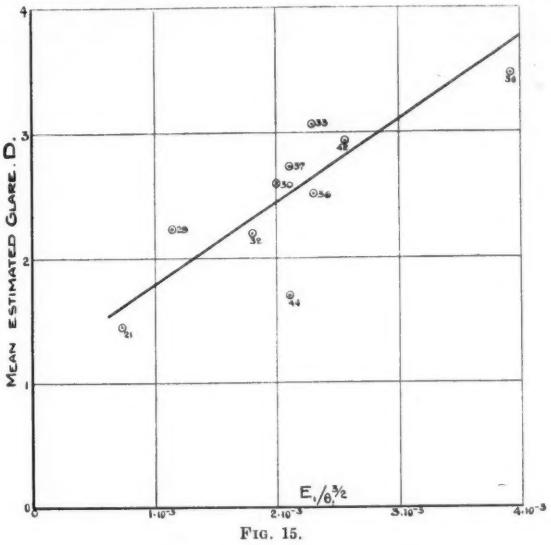

FIG. 15.

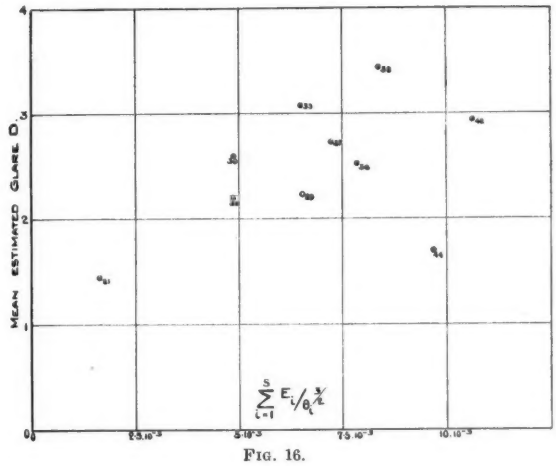

FIG. 16.

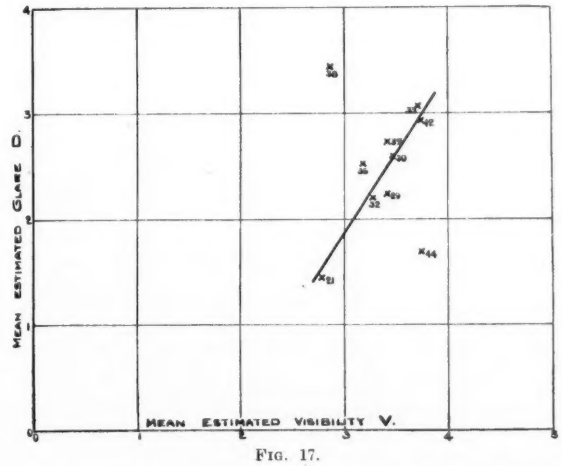

FIG. 17.

to each lamp is 300 against 500 for other installations (except the gas installation with consumption of 25 cubic feet). Another difference between installations 21 and 38

* From this point onwards, only the computed values on the basis of the $k = 4 \cdot 16$, $n = \frac{3}{2}$ formula will be employed.

and the others is that the illumination diversities of the former are 5 and 2, respectively, against diversities for the latter ranging from 10 to 20. It is of interest to compare the observers' visibility and glare estimates, and a graph relating the mean figures is given in Fig. 17. The straight line drawn in the figure, indicating steady increase of estimated maximum glare with estimated visibility, represents the data satisfactorily, except for installations 38 and 44. As already pointed out, the mean glare estimate for No. 44 is anomalously low, and it is of interest to note that if instead of the observed value, 1·7, the value 2·7 had been obtained, the No. 44 point would be brought into line with the other installations in both Figs. 15 and 17. It was not found that, in Test B, installation 44 gave an exceptionally low threshold compared with the computed value. It may be inferred, therefore, that some factor peculiar to this installation influences the estimation of glare, although having no effect on the threshold, and the estimate of the general level of visibility. Installation No. 44 differs from the others in two important respects: (1) it has a very low mounting height, 15 feet, not permitted by the specification in an installation with 0·25 foot-candles min. hor. illumination, and (2) it is a gas installation. The former of these is not likely to explain the anomaly, as the low mounting height is already allowed for in the computed effect of glare. If the latter is the cause, then we are led to the suggestion that of two lamps having the same effect on eye sensitivity, one may be judged to be the less glaring. It would be unwise, with the scanty evidence available, to press this point further at the present time.

There is no reason for thinking that the glare estimate for installation 38 is anomalous, for it fits quite normally into the graph of Fig. 15.

TABLE V.

Installation	$\frac{E_1/\theta_1^{\frac{3}{2}}}{\sum_{i=1}^{s} E_i/\theta_i^{\frac{3}{2}}}$
21	·448
29	·164
30	·408
32	·371
33	·352
36	·294
37	·290
38	·469
42	·242
44	·273
	Mean ·331

The significance of the straight line relation between D and V (omitting for the moment No. 38 and accepting the above explanation of an anomalous D estimate for No. 44), is not altogether easy to understand. It appears that for the test installations which include fittings of very different types, the type of fitting and the lamp wattage affect visibility in the same sense as they affect glare. For installation 38 the estimated visibility is much lower than would be expected for the observed D value, on the basis of the results for the other installations. No. 38 is special in that the fitting is asymmetric highly directional (diversity of 2) and contains a lamp of only 300 watts. Each of these special features is possessed in some degree at least by other installations, although in no other case are all three present together. It is not possible therefore to pick on one characteristic of the installation as accounting for the low value of V.

In connection with the above, it should be emphasized that, although evidence has been submitted to show that the estimate of glare D does correspond to the effect on eye sensitivity of the nearest lamp, the estimated visibility has not been correlated with any derived magnitude representing the actual ease with which objects are seen. We do not know how to define such a visibility figure at the present time, and although we may think there must be a method for doing this, we cannot say that the estimated visibility would be simply related to the figure obtained thereby.

General Discussion and Conclusions.—The results of the investigation are of three kinds: (1) information on the methods and technique of appraising street lighting and of applying the results of laboratory measurements of thresholds to actual installations; (2) specific and comparative data for the ten installations tested; (3) the bearing of the results on the B.E.S.A. Specification.

(1) It has been shown that by the use of a set of contrast discs in the manner described, outdoor threshold measurements can be made which correlate well with the thresholds computed from formulæ established in the laboratory, although the absolute magnitudes of the thresholds by the two methods may differ by a constant factor, the laboratory threshold being smaller. Of the two laboratory formulæ available for evaluating the equivalent background brightness of a given glare condition, the Holladay expression $\beta = B + 9{\cdot}2\,\Sigma\frac{E}{\theta^2}$ gives thresholds $\frac{1}{2{\cdot}5}$ of the values obtained outdoors, the writer's expression $\beta = B + 4{\cdot}16\,\Sigma\,\frac{E}{\theta_2^3}$ on the other giving thresholds $\frac{1}{4{\cdot}4}$ times the outdoor values. The correlation between observed and computed thresholds is, however, better with the latter formula.

The selection by observers of a position at which glare is a maximum is found to accord with the assumption that cognisance is taken of the nearest lamp only and that the chosen position is where the contribution $k\,\frac{E_1}{\theta_1^n}$ of this lamp to the expression for β, has a local maximum which in most cases is where $k\,\frac{E_1}{\theta_1^n}$ has its greatest value in the span. Considerably better agreement between observed and computed positions is obtained using the expression $4{\cdot}16\,\frac{E_1}{\theta_{12}^3}$. As it is difficult to believe that the observer's selection is based on some rough visibility test, it is concluded that a sensation of ocular discomfort is experienced the variations of which are in the same sense as those of the term in the formula measuring the effect on eye sensitivity of the nearest lamp, and which is such that the discomfort produced by the different lamps is separately evaluable. The intensity of glare estimates support this suggestion.

There is evidence for thinking that in the case of lamps producing the same depression of eye sensitivity the appearance of glare to an observer may not be the same for different types of light source.

(2) The observed brightness difference thresholds range from 1 to $3{\cdot}10^{-3}$ candles/square feet. We inquire a little into the factors giving rise to this variation. The relative importance of the nearest lamp in determining the threshold is shown in Table V, where the ratio of the nearest lamp contribution, $4\cdot16\times\frac{E_1}{\theta_{12}^3}$, to the sum of the contributions of all the lamps, $4{\cdot}16\,\Sigma\,\frac{E_i}{\theta_{i2}^3}$, is given for the mean estimated position of maximum glare. For installation 29, which is the only one with housing type fitting, the ratio is smallest, the nearest lamp contributing only 16 per cent. The percentage contributions of the nearest lamps are greatest in installations 21 and 38, which are highly directional. The average value of the ratio is 33 per cent. Thus the nearest lamp is not by any means the sole determining factor in the glare effect. Other important factors which arise are the number of lamps in the field of view and the slope and bend of the road.

It has been realized in making the present calculations that these, which may be termed accidental factors, are capable of seriously modifying the threshold value so that results deduced for an ideal straight level street bear little relation to the values obtaining in practice. A very clear case of this is presented by installation 21. A reference to the photograph Fig. 7 shows that there is a large

number of lamps (15) in the field of view, and if the road were perfectly straight the computed threshold for the conditions of Test B would be exceptionally high. Actually the bend in the road results in the sum of the effects of all lamps after the fourth contributing only about 12 per cent. to the glare term in the β formula, and the computed threshold is the lowest of all the test installations. Another interesting case is that for installation 30, where there are only four light sources in the field of view, a sharp turn in the road cutting off the more distant lamps. The computed threshold is the second lowest, but a similar installation (same lighting fittings, spacing, mounting height, road width) on an ideal road would have led to a considerably higher threshold value.

Accidental factors will be expected to have some influence also in controlling the estimates of general visibility. The reflection factors of the road surface and the walls of houses are likely to be of importance here. Perhaps the advertisement hoardings in installation 33 have something to do with the rather high estimate of visibility.

The empirical relation which seems to obtain between estimated maximum glare and estimated visibility has already been discussed and must be left as a rather puzzling observational result.

(3) The method given in the B.E.S.A. Specification for computing a glare figure fails simply because, for the ten test installations, the amount of glare is much less than that which the specification regards as undesirable. It must be remembered that the specification method is based on the determination of the glare from one lamp only, and can only represent about a third of the total glare effect on vision. On the other hand, the assumption underlying the glare clause is probably that a high glare value for the nearest lamp usually goes with a high total glare, and the critical number 10 was presumably chosen empirically as the G value at which the total glare becomes objectionable. It may be questioned if the first assumption is justifiable, for the maximum glare from one lamp will depend principally on the candle power at the peak in the polar curve of the fitting, whilst that from the other lamps will depend on the candle power in directions making small angles with the horizontal. Passing this point over for the moment, it may be asked whether any of the ten test installations, for all of which the G value is less than 10, would be considered in practice as objectionably glaring. For installation 38, the observers' estimated glare was greatest, and for this installation the B.E.S.A. method would give a G value between 5 and 6, the maximum in the *m* curve lying just within the lowest constant glare locus (G = 6) in the B.E.S.A. diagram for Class D streets. The observers were asked to adjudge only the relative not the absolute seriousness of glare, but, from the opinions expressed, the writer has no hesitation in saying that most observers regarded the glare in installation 38 as objectionable. In that case the critical G value given in the specification must be too high.

The mid span horizontal illuminations for the ten test installations range from 0·08 (No. 32) to 0·25 (No. 44). It is of interest to find out if the estimated visibility correlates with the mid span horizontal illumination. On plotting the appropriate graph no correlation between the two magnitudes was detectable. The mid span illumination is taken in the B.E.S.A. Specifications as the quantity by means of which classification of installation is carried out. It is expressly pointed out that no suggestion is made that the merit of the installation is measured by this quantity. Our result indicates merely that, in fact, there is no direct relation between estimated visibility in the street and mid span illumination, at least for this admittedly rather restricted range of the latter quantity. (There is a similar absence of correlation between estimated visibility and maximum or average illumination.)

Finally, the specification lays down for each class of installation, as determined by the mid span illumination, a minimum mounting height. Installation 44 is the only one of the ten test installations which does not conform to the specification in this respect. The estimated visibility for this installation is one of the highest. The estimated maximum glare is anomalously low, but a probable reason for this may exist in the character of the illuminant. It would be unjustifiable to conclude from this single result that the minimum height prohibition of the specification is unsuitable; it is, however, an observational fact to be remembered.

Acknowledgments.—It is scarcely necessary to point out that an investigation of this kind could not have been carried out except with the active co-operation of a large number of individuals. It is a pleasure to the writer to express in this place his thanks and acknowledgments to all those gentlemen who gave their services either as assistants, observers, or as providers of facilities without which the tests would have been impracticable. In particular, to Mr. Colquhoun personally and to his Staff in the Sheffield Lighting Department, special thanks are due for their interest, and willingness to aid in every way in the preparations and carrying-out of the tests. The present account is published by the kind permission of the Department of Scientific and Industrial Research.

Illuminating Engineering Society, U.S.A.

TWENTY-THIRD ANNUAL CONVENTION.

The twenty-third annual convention of the American Illuminating Engineering Society will be held this year in Philadelphia, from September 24th to 27th inclusive. A comprehensive series of papers has been secured. A special feature will be discussions of methods of bringing about a closer understanding between architects and illuminating engineers. A session is to be devoted to the observance of "Light's Golden Jubilee," commemorating the 50th anniversary of Edison's work on the incandescent electric lamp. Another session is being devoted mainly to "lighting service." At other sessions 25 papers dealing with various aspects of natural and artificial lighting will be read.

A special feature on this occasion will be a "Pre-Convention Meeting," on September 23rd. This will be primarily a gathering of central station lighting men, at which such topics as lighting specifications, residence lighting, lighting service and "selling foot-candles" will be reviewed.

Reports on Lighting in France

Last year we commented upon the enterprising action of the Committee on Progress of the *Société Francaise des Electriciens* in arranging for a series of reports reviewing the lighting field. This practice has again been followed in the present year, and the series of reports appears in the *Bulletin* of the Society (No. 95, July, 1929). Monsieur M. Leblanc summarizes some tests on mercury-vapour lamps, and M. Maisonneuve deals with electric incandescent lamps. M. Jouast reviews progress in photometry. Dr. Haas discusses physiological optics. Other subjects reported upon include: The lighting of studios (M. Cabet), luminous signs (M. Fonseque), the lighting of aerial routes (M. Abadie), and lighting propaganda (M. Cohu). M. Cabet's data illustrate the tendency to adopt incandescent lamps for kinema studio work, owing to their noiselessness, but the great heat produced is still a difficulty. There seems now to be a movement towards the use of lamps of moderate power instead of relatively few very powerful units. M. Cohu's paper reviews the work of the *Société pour le perfectionnement de l'éclairage*, whose work, like that of similar concerns in other countries, seems to be progressively extending.

The Effects of Monotony of Work

A preliminary survey on the above subject by Messrs. S. Wyatt, J. A. Fraser and F. G. L. Stock has been issued by the Industrial Fatigue Research Board.* Avoidance of boredom is, nowadays, a very real problem. It is possible to be both busy and bored. The uninteresting and mechanical work of the world must be done by someone, and, unfortunately, with modern methods this form of work tends to increase. Reference in this report to the researches of others shows that there is already quite a literature of boredom. The authors investigated various repetitive processes, such as filament winding and inserting, soap wrapping, chocolate packing, tobacco weighing, etc. Of 49 operatives examined in this inquiry only 13, or about a quarter, were able to say that boredom was seldom or never experienced. Boredom seems to be most marked in the semi-repetitive processes. It is less liable to occur when the work is entirely automatic (for then thought can be detached to other subjects and conversation with other employees is possible), and is less experienced when the work is entirely concentrated on the task (for then unexpected and varied situations arise and the operative has no time to dwell on unpleasant features of the work). Boredom is less liable to arise (*a*) when the form of activity is changed at suitable intervals, (*b*) when the operatives are paid according to output produced instead of time worked, (*c*) when the work is conceived as a series of self-contained tasks rather than as an indefinite and apparently interminable activity, (*d*) when the operatives are allowed to work in compact social groups rather than as isolated units, and (*e*) when suitable rests are introduced.

The Lighthouse Conference

The International Lighthouse Conference which recently took place in London was an important event which well illustrates the tendency towards exchange of experience on technical subjects by experts of various countries. The proceedings were informal, and no great effort appears to have been made to give publicity to the discussions, and *The Electrical Review* has done good service in furnishing a good report of what occurred. The chief impression one receives is the important part now played by electricity in promoting the safety of shipping, not only in its application in lighthouses and lightships (where other illuminants, too, continue to play their part), but also by wireless telephony and telegraphy and the wireless control of distant unattended apparatus.

Absorption of Light by Fog

A research described by L. P. Graneth and E. O. Hulbert in *The Physical Review* (July, 1929) bears on the debatable question which kind of light can best penetrate a foggy atmosphere. These experiments deal with relatively thick fog sufficiently dense to obliterate light sources within quite a short distance. In these circumstances a red light appears to be only very slightly better than blue light in penetration. It is pointed out, however, that the conclusions do not necessarily apply to mists or haze due to moisture, smoke, dust, etc., over long distances. In such circumstances the selective absorption of blue, probably due to Rayleigh scattering, is often much more pronounced than in the case of fog; the existence of this selective absorption is familiar to photographers.

The same issue of *The Physical Review* contains a contribution on the attenuation of ultra-violet light by the lower atmosphere. The degree of absorption depends materially on wavelength. For wavelengths from 5,000 to 3,000 *A*. the absorption was too slight to be observed at distances up to 400 metres; but for wavelengths below 2,800 *A*. there is marked selective absorption, and the absorption in the lower atmosphere at 2,200 to 2,050 *A*. is great enough to prevent sunlight of these wavelengths from penetrating to sea-level.

* Report No. 56 (His Majesty's Stationery Office, 2s. net).

London's Black Building

The Illustrated Carpenter and Builder draws attention to the rather singular architectural scheme of the National Radiator Co. "Ideal House," which is stated to be the first example of a building deliberately constructed of black material. It is faced entirely with Swedish black granite in large slabs of about 5 inches in thickness. Londoners are familiar with buildings which have assumed an almost black appearance under the influence of smoke and soot, but a building deliberately designed in this sombre hue is a novelty. The black surface is relieved by colour enrichment consisting of vitreous enamel on bronze and by gilt glazing bars, and the design is described by our contemporary as a brilliant piece of work. Nevertheless we agree with it in hoping that this style of decoration will not become usual. Streets lined with "all-black" buildings would be sombre indeed, and would accentuate greatly the present difficulties of effective street lighting, besides making floodlighting impracticable. Fortunately the precedent is not likely to be widely followed, for the success of the scheme depends essentially on the building standing out from others. Such an exterior is only tolerable when it stands alone.

An Imposing Lighting Installation

According to the accounts that have reached us, the lighting of the Atlantic City Convention Hall, which is stated to be the largest room in the world, is on an impressive scale. This vast building comprises an entire city block 350 ft. wide and 650 ft. deep. Within its walls are a theatre, ballroom, auditorium, and parking accommodation for 400 cars. It is estimated that the auditorium alone would seat 40,000 people, while the entire population of Atlantic City could be accommodated in the entire building. The lighting system comprises about 275 circuits for the main auditorium, ballroom and the exterior of the building. These circuits vary in capacity from the 100-watt "trouble lamp" in the hands of workmen to the 30,000-watt floodlight systems erected on the trusses of the main auditorium. Approximately 1,800,000 watts will be expended on the lighting of the auditorium. The roof of this room is 135 ft. above the floor at its highest point. It is supported by ten pairs of three trusses weighing 220 tons per pair, with a clear span of 350 ft. Inside the trusses, which are 12 ft. wide, and large enough for a man to climb a ladder which extends their entire length, there are placed 540 1,500-watt floodlight projectors, spaced 14 ft. apart. Lighting in combinations of white, amber, red and blue colours is available, and the projectors are controlled by a system designed by the Westinghouse Electric and Manufacturing Company.

Treatment of Smallpox by the Withdrawal of Light

Treatment with ultra-violet light has proved of value in many diseases, but there are some cases where the presence of these rays is highly prejudicial. Dr. R. King Brown, in *The British Journal of Actinotherapy and Physiotherapy*, remarks that in the active stages of smallpox it would probably have the most dangerous effects. There is, in fact, a method of treating the disease which is based on the vigorous exclusion of all actinic rays, patients being confined in a room equipped with red screens, which only allow inactive rays to enter. The choice of the red screen needs considerable care, however; it has been found that the relatively minute traces of active light which penetrate many red materials are sufficient to cause scarring, and this perhaps explains the differences in experience of various operators. The same idea has been tried in the case of measles, erysipelas and scarlet fever, but apparently without good results. Possibly the smallpox poison renders the skin highly sensitive to light, and thus influences the severity of the suppuration and scarring.

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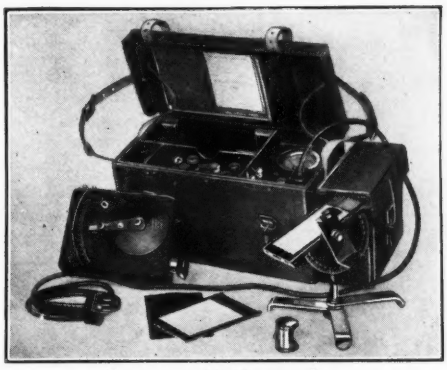

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